Manual Brushing for Forest Vegetation Management in British Columbia: A Review of Current Knowledge and Information Needs

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The HVM TAC was established in 1990, under funding from the Sustainable Environment Fund – Forest Renewal Initiatives Program, to establish a long term, coordinated research and extension program that improves the ability of forest practitioners to prescribe and implement vegetation management treatments. Representatives on HVM TAC include the Ministry of Forests (Forest Science Research Branch, Silviculture Branch, and Forest Regions), Ministry of Environment, Lands and Parks (Wildlife Branch), and Forestry Canada. Since its inception, a total of 40 projects have been supported province-wide.

The current vegetation management research goal of HVM TAC is to support the acquisition, communication, and application of information needed for implementing effective vegetation management prescriptions consistent with sustainable and integrated management of forest resources.

The five year strategic plan for vegetation management outlines six priority areas for investigation. They are:

- prediction and diagnosis of vegetative competition problems;
- effectiveness of treatment options;
- ecology of crop and non-crop species;
- silvicultural benefits and impacts of treatments;
- impacts of treatments on non-timber resources; and
- development of tools to assist resource managers in the selection and evaluation of treatments.

Further information about the program can be obtained from Ministry of Forests, Forest Science Research Branch, 31 Bastion Square, Victoria, B.C. V8W 3E7.

Manual Brushing for Forest Vegetation Management in British Columbia:

A Review of Current Knowledge and Information Needs

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SUMMARY

Sixty thousand hectares of British Columbia's forest land were brushed in 1989/90, at a total cost of approximately $25 million. Manual brushing accounted for 37% (22 000 ha) of the area brushed, and 52% of the costs ($12 million). Increased expenditures on manual brushing are expected with increased commitment by both the Ministry of Forests and industry to improving the survival and growth of newly established forests and with reductions in the use of herbicides on forest land.

Some hardwood species (such as red alder, paper birch, trembling aspen, and black cottonwood) can be effectively controlled using cutting or girdling treatments. Manual cutting treatments can also be used effectively on slow-growing shrubs, such as white-flowered rhododendron, false azalea, and *Vaccinium* spp. However, single cutting treatments are generally not effective for controlling fast-growing shrubs or herbaceous vegetation. Instead, to control herbaceous vegetation, repeated treatments may be necessary within the same growing season. Bending herbaceous stems, rather than severing them, may be effective for reducing competition for light and physical damage to crop seedlings, and may result in less regrowth during the year of treatment than would cutting treatments.

Factors that influence the utility of manual brushing are: (1) the response of target species to manual treatment; (2) the growth response of the crop trees; (3) damage to the crop trees; and (4) administrative constraints limiting the use of manual brushing. Response of target vegetation varies with species, environmental conditions, and method and timing of treatment. Reports conflict on the growth response of crop trees released by manual cutting, and the information relating to the optimum stand age for treatment is not available. Damage can occur to crop trees from tools used for manual brushing, from sunscald caused by the sudden opening of the canopy, and from slash and animals. Because it is a labour-intensive undertaking, the use of manual brushing may be limited by the availability of contractors who do this type of work.

The cost of manual cutting or girdling is highly variable. On a province-wide basis, the average cost of all manual brushing treatments is $541/ha compared to an average of $289/ha for chemical brushing treatments. However, because of differences in the areas treated using manual and chemical methods, these relative costs may not reflect real differences. Factors that influence costs include: the composition, size and density of the brush or target species, the relative height of brush and crop species, terrain, availability of contractors, and specifications of the contract.

Further research is required to document the effectiveness of single and multiple manual brushing treatments, especially in comparison to herbicide treatments, and to identify optimum times for treatment.

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1 INTRODUCTION

In British Columbia, forest vegetation management activities have steadily increased over the last decade. Total Crown forest land brushed in 1980/81 was 3000 ha. In 1990/91, a total of 77 000 ha of Crown forest land were brushed in British Columbia (Figure 1). The B.C. Ministry of Forests estimates that approximately 80 000 ha of forest land will require brushing each year over the next decade.

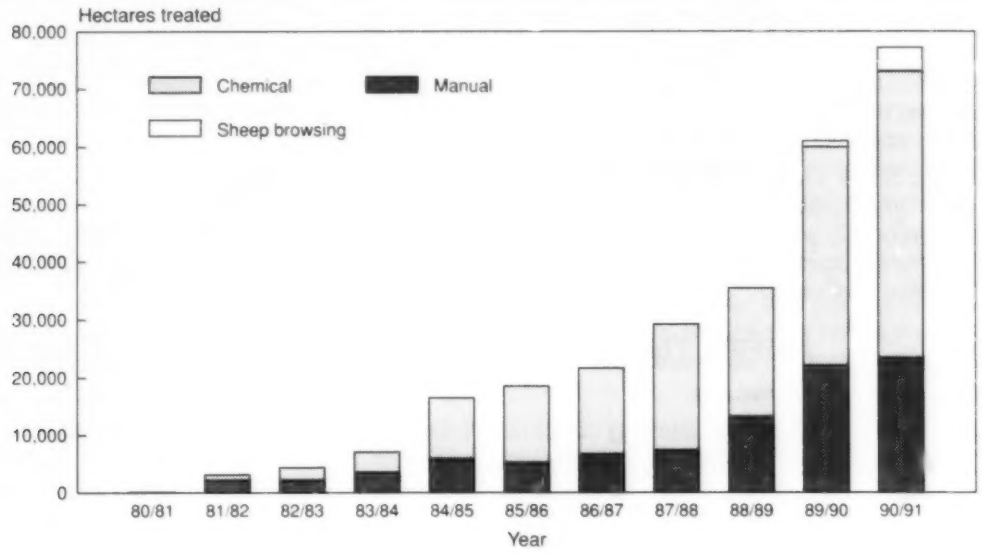

FIGURE 1. Brushing activity in British Columbia on Crown forest land, 1980–90.
Sources: B.C. Ministry of Forests Annual Reports, 1980/81 to 1988/89. Silviculture Activity Summary, B.C. Min. For., Silv. Br., 1989/90. Unpublished data.

In 1989/90, manual brushing treatments (cutting, clipping, girdling, etc.) were used on 22 000 ha. This area equals 37% of the total area brushed in the province in that year. One-third of the 1989/90 provincial manual brushing program was done in the Cariboo region (Table 1), while 15–20% of the program was conducted in each of the Vancouver, Prince Rupert and Kamloops regions. Very little manual brushing was conducted in the Nelson and Prince George regions; these two regions account for only 12.5% of the total manual brushing program in 1989/1990.

TABLE 1. Area of manually brushed Crown forest land in British Columbia, 1989/90

Region	Cariboo	Kamloops	Nelson	Prince George	Prince Rupert	Vancouver	Total
Ha brushed	7435	4341	1604	1169	4145	3449	22 135
% of Total	33.6	19.6	7.2	5.3	18.7	15.6	100

Source: Silviculture Activity Summary, Silv. Br., B.C. Min. Forests, 1989/90. Unpublished data.

Approximately $25 million was spent on brushing Crown land in 1989/90. Slightly less than half of this total, $12 million, was spent on manual brushing. The remainder was spent on chemical brushing. The average cost for manual brushing in 1989/90 was $541/ha compared to $298/ha for chemical treatments.

This report reviews available information on manual brushing treatments used in British Columbia. Treatments considered here include clipping, cutting, girdling and physical knockdown treatments. Hack-and-squirt or cut stump methods are mentioned only in comparison to non-chemical manual methods. Although the geographical focus of this report is British Columbia, relevant literature and research found from Washington, Oregon, and Alberta is also included.

A review of the tools used for manual brushing is beyond the scope of this report. For further information, readers are referred to *A Guide to Vegetation Control Equipment*, FRDA Handbook 005, by J. Boateng and G. Ackerman.

Vegetation management is used to control non-crop vegetation so that the survival and growth of crop species are improved. Non-crop vegetation competes with crop species for light, water and nutrients. However, non-crop vegetation can also benefit crop seedlings by moderating microclimate (e.g., providing shade, reducing frost problems), adding nutrients to the soil, and providing an alternative food source for animals. Abundant non-crop vegetation may cause physical damage to crop trees and may also harbour tree pests.

Silviculturists have a variety of techniques at their disposal for vegetation management. These include prescribed burning, mechanical site preparation, herbicides, manual brushing, and animal grazing. Immediate post-harvesting site preparation and planting of large, vigorous stock appropriate to the site can reduce the need for future vegetation management treatments.

Four main factors influence the utility of manual brushing treatments: (1) effectiveness of controlling the non-crop vegetation; (2) growth response of crop trees that are released; (3) potential damage to crop trees; and (4) administrative constraints. The cost of manual brushing compared to other treatments also affects the choice of brushing treatment.

2 EFFECTIVENESS OF MANUAL BRUSHING

2.1 Manual Cutting of Hardwoods

Manual cutting of most hardwoods (e.g., cottonwood, bigleaf maple, aspen and birch) is generally not effective (Table 2). Following cutting, most hardwoods sprout rapidly and the number of shoots per stump increases greatly.

TABLE 2. Effectiveness of manual brushing treatments for controlling selected hardwoods

Species	Effectiveness of manual cutting (single treatment only)	Most effective time to cut	Comments
Cottonwood	–sprouts may grow 1.5–3 m in height in one growing season –stems may increase 25× in number	–mid-June to mid-August (?)	–considered a crop species in some areas –may be used as a nurse crop to reduce weevil damage –basal sprouts provide forage for snowshoe hares and may help reduce hare feeding damage on conifer seedlings
Bigleaf maple	–sprouts may grow between 2 and 3 m in two growing seasons –stems may increase up to 50× in number –forms multi-stem clumps which cover large areas	–cutting in mid- to late summer may slightly reduce sprouting	–pre-harvest treatments may be more effective than post-harvest treatments –double-bagging and stapling dark plastic over stumps to eliminate light has been tested, although problems with tears in the bags have limited success to date
Aspen	–sprouts and suckers grow 1.5-3 m in one growing season –5× increase in sprouts after cutting	–reports range from summer to dormant season	–moisture status of the site may affect sprouting ability
Birch	–sprouts vigorously –can regrow to 40–70% of pre-treatment height in one growing season	–unknown	–manual cutting used to produce coppices in Salmon Arm area
Red alder	–effective if: alder >5 years old; cut at height of <20 cm; cut during prescribed window –vigorous sprouter –1.5–3 m in one growing season	–window starting 8–10 weeks after bud break and ending 8 weeks later (July to early September on south coast of B.C.)	–moisture status may affect sprouting ability; may be more effective on drier sites

For example, cottonwood is known to sprout vigorously (Haeussler *et al.* 1990). After one growing season, cottonwood that had been cut with a chainsaw had an average of 25 sprouts per stem.[1] Reports on sprout height growth vary from 1–2 m (B. D'Anjou, pers. comm., 1990) to 2–3 m (P. Chalifour, pers. comm., 1990) in one growing season. Reports on the best time to cut cottonwood vary from June[2] to July/August (G. McKee, pers. comm., 1990).

Bigleaf maple also sprouts vigorously after cutting or disturbance from logging. A variety of post-harvesting manual treatments have been tested for controlling bigleaf maple, but so far success has been very limited. These include cutting, enclosing stumps in black plastic bags to eliminate light, and girdling (S. Dunn, pers. comm., 1990). The crowns of bigleaf clumps may be reduced by half during the first growing season after cutting (Wagner 1987) but, after two growing seasons, sprouts may range in size from 2 to 3 m (Roberts 1980; Boateng and Ackerman 1988), and there may be up to 50 stems per stump (Boateng and Ackerman 1988).

Only small differences in bigleaf maple's sprouting ability were reported when it was cut during different times of the growing season, and the differences were unlikely to reduce competition significantly (Roberts 1980; Wagner 1987).

Pre-harvest measures may be more successful than post-harvest measures. Current research on the biology and growth of bigleaf maple should provide useful insights into pre- and post-harvest treatments (T. Harrington, pers. comm., 1990; J. Zasada, pers. comm., 1990). Greater care during logging, to minimize disturbance to bigleaf maple, as well as pre-harvest cutting treatments, may be useful for controlling this species.

Aspen suckers profusely following cutting, usually producing more than twice as many suckers as does girdled aspen (Schier 1978; Haeussler *et al.* 1990). Sprout growth from 1.5 to 3 m in height, with five sprouts per cut stem, has been reported (P. Chalifour, pers. comm., 1990; S. Clayton-Brown, pers. comm., 1990). Site factors may influence aspen's suckering ability: on very dry to dry (xeric) sites in the Cariboo Region, aspen usually does not sucker (J. Perry, pers. comm., 1990).

Timing may influence the effectiveness of cutting aspen. To minimize sprouting, aspen is cut during July and August in the Williams Lake District (G. McKee, pers. comm., 1990). As well, reduced aspen suckering was reported when it was cut during the dormant season (F. Philpot, pers. comm., 1990).

Birch is also a vigorous sprouter. It can apparently regrow 40–70% of pre-treatment height in one growing season (S. Simard, pers. comm., 1990). Stumps may have over 100 sprouts each 1 year following cutting, depending on the size of the stump.

Manual cutting can be effective for controlling red alder. Age of the alder, time of cutting, and height of the cut influence the response of red alder to cutting treatments. A prescription developed for Siuslaw National Forest is reported to have worked well for the last three growing seasons (DeBell and Turpin 1989). While the age of the alder (at least 5 years old) and height of the cut (20 cm or less) will likely be the same in British Columbia, refinements on the treatment timing may be necessary. DeBell and Turpin suggest scheduling cutting for a window beginning 8–10 weeks after bud break and ending about 8 weeks later. Pendl and D'Anjou (1990), on the south coast of British Columbia, found that late August or early September cutting effectively controlled red alder. Trials and local knowledge of alder bud break are required to refine or adjust this prescription to other areas of the province.

2.2 Girdling Hardwoods

Both pre- and post-harvest girdling of hardwoods are becoming common, particularly on stems larger than 5 cm in diameter. However, girdling stems with a clumpy growth habit (e.g., willow) and small stems is difficult and time-consuming. Reports indicate that girdling is most effective for controlling cottonwood and aspen (Table 3).

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[1] Hanlon, L. 1987a. Efficacy testing of Velpar-L (Hexazinone) for brushing and weeding spruce plantation: interim report. B.C. Min. For., Nelson Region, Nelson, B.C. Unpubl. report. SX86704N.

[2] Herring, L. 1984. Conifer release with manual cutting and hexazinone gridballs. Expert Committee on Weeds (ECW). West. Canada Section Meet., Dec. 6–8, Winnipeg, Man. Res. Report, p. 262. Unpubl. report.

TABLE 3. Effectiveness of girdling for controlling selected hardwoods

Species	Effectiveness of girdling	Most effective time to girdle	Comments
Cottonwood	–preliminary results show it may be effective		–see Table 2
Bigleaf maple	–post-harvest girdling not effective because of large numbers of stems requiring treatment		–pre-harvest treatments may be more effective than post-harvest treatments
Aspen	–can be effective –suckers far less compared to cutting	–preliminary results indicate June may be the most effective time	–both pre- and post-harvest girdling show promise –moisture status of the site may affect suckering ability –aspen takes 1–3 years to die following girdling
Birch	–significant sprouting occurs when girdled at breast height –difficult to girdle because stems often are not round		
Red alder	–reports mixed –may be effective on larger stems (>5 cm)	–some reports suggest bridging may be a problem if girdled during active sap flow (May–July)	–moisture status may affect sprouting ability; treatment appears to be more effective on drier sites –alder takes 1–3 years to die following girdling

Effective control of **cottonwood** by girdling has been reported in two trials in the Cariboo Forest Region (J. Perry, pers. comm., 1990). In aspen, both pre- and post-harvest girdling show promise. Unlike cutting, girdling does not promote root suckering, although the aspen may still sprout (Haeussler *et al.* 1990). Bancroft (1989) reports that pre-harvest girdling of aspen is effective, with the aspen taking between 1 and 3 years to die following treatment. The best timing between pre-treatment and harvest is unknown. Preliminary results from a post-harvest trial in the Prince Rupert Region indicate that girdling in June may be the best time to reduce sprouting.[3]

Post-harvest girdling of **bigleaf maple** has not been successful to date (B. Granger, pers. comm., 1990), but there is interest in testing the effectiveness of pre-harvest girdling treatments (B. Bancroft, pers. comm., 1990; B. Granger, pers. comm., 1990).

Birch can be difficult to girdle because its stem often is not circular (J. Perry, pers. comm., 1990). Significant sprouting may also be a problem (R. Enfield, pers. comm., 1990).

Information from research and operational girdling treatments of **red alder** show that this treatment has mixed success. Reports on the length of time alder takes to die vary from 1 to 3 years (Beese;[4] S. Dunn, pers. comm., 1990; B. Wilson, pers. comm., 1990) and reports on the best time to girdle are conflicting. Eastwood[5] found that bridging of girdles was common if red alder was girdled during active sap flow — unless workmanship was flawless — but she had excellent results at other times of the year.

On the other hand, Weaver (1983) intentionally girdled stems during active sap flow, stating that it was known to be physically easier to do. He obtained good results using the Vredenburg girdler. Some researchers have reported that red alder bark is easily removed during the active sap flow season (F. Newhouse, pers. comm., 1990) . Others have girdled in January and still had bridging problems, although the treatment seemed to be effective (A. Banner, pers. comm., 1990). Following girdling, stem breakage may occur at the point

[3] Coates, D. and F. Newhouse. 1990. The effect of girdling and manual cutting on the sprouting and suckering capacity of young aspen in the SBS zone in the Prince Rupert Region: first year progress report. B.C. Min. For., Prince Rupert Region, Smithers, B.C. Unpubl. report.

[4] Beese, W.J. 1985. Manual alder control: a review with recommendations. Presentation to the MacMillan Bloedel Annual Foresters Meet., Jan. 17–18, Qualicum, B.C. Unpubl. report.

[5] Eastwood, J. 1985. Assessment of alder girdling operations final report. B.C. Min. For., Silv. Br., Victoria, B.C. Unpubl. report. SX84708.

where the alder stem is girdled (Williams 1987; Pollack and LePage 1990). The resulting slash accumulations may restrict travel by wildlife and humans, seedlings may be damaged, and alder may resprout if breakage occurs during the 1st year.

2.3 Manual Cutting of Shrubs

Cutting relatively fast-growing shrubs appears to provide only short-term control of competing vegetation (Table 4). Sitka alder, willow, thimbleberry, salmonberry, and other shrubs generally recover to untreated height and cover within 2 years of treatment. Cutting may also cause increases in the number of shoots and total cover. As a result, repeated cutting may be necessary to achieve acceptable levels of control. However, little information is available on the effectiveness of repeated cutting in these communities.

TABLE 4. Effectiveness of manual brushing treatments for controlling selected shrubs

Species	Effectiveness of manual cutting (single treatment only)	Most effective time to cut	Comments
Sitka alder	–can effectively reduce cover and height to 4 or 5 years on dry (pinegrass) sites –can return to pre-treatment levels within one growing season –observations show that on wet sites it may sprout throughout the growing season		–moisture status of site affects sprouting ability –a clumpy growth habit and small diameter stems make girdling this species difficult
Willow	–sprouts up to 1.5 m in height in one growing season –3–5× increase in number of stems	–late summer (?)	–a clumpy growth habit and small diameter stems make girdling this species difficult and ineffective –important species for moose forage –basal sprouts provide forage for snowshoe hares and may help reduce hare feeding damage on conifer seedlings –reductions in willow cover may not be enough to benefit conifer seedlings
Thimbleberry	–can regrow to 90% of pre-treatment height (60–100 cm in 1 year –cutting can result in increased numbers of shoots and increased cover of thimbleberry	–may be slight reduction in sprouting if cut in mid-July –mid-summer (July) cutting will provide control only until the following spring	
Salmonberry	–can regrow to 60–90% of pretreament height (up to 1 m) in 1 year –cutting twice in one season may be effective –preliminary results show cutting 2 years before harvest may help reduce sprouting		–site factors may influence sprouting ability –may be a good candidate for pre-harvest control
Salal	–expected to be a significant sprouter as a result of extensive root system		–manual pulling may be effective but may not be practical
White-flowered rhododendron	–effective –can increase up to 6× number of stems but sprouts grow slowly		–mechanical site preparation and prompt planting may effectively control this species
False azalea	–effective –slow-growing species		–mechanical site preparation and prompt planting may effectively control this species
Vaccinium spp.	–effective –slow-growing species		–mechanical site preparation and prompt planting may effectively control this species

Sitka alder is a vigorous sprouter following cutting. Simard (1989) found that Sitka alder clumps sprouted to a mean height of 70 cm and a mean diameter of 73 cm in one growing season.

Anecdotal evidence suggests that sprouting ability is influenced by the moisture status of the site. Manual cutting of **Sitka alder** has been observed to be effective on drier sites[6] and the best time to cut on these sites is when moisture stress is highest (during the hot part of the summer) (S. Clayton-Brown, pers. comm., 1990; L. Gilloch, pers. comm., 1990). Other observations show that the time of cutting does not affect Sitka alder's vigorous sprouting ability (D. Lloyd, pers. comm., 1990). On moist sites, Sitka alder may even sprout all growing season (J. Przecek, pers. comm., 1990).

Willow is a very vigorous sprouter and one manual cut of this species does not give effective control. Pollack *et al.* (1990) report that sprouts reached heights of 74 cm within two seasons of cutting, and there were 2.7–4.2 sprouts per cut stem. Cutting in late summer, however, may reduce willow's sprouting ability.[7] Manual brushing does appear to be an excellent way to improve browse availability for moose.

Cutting stimulates sprouting of **thimbleberry.** This species can recover to its pre-treatment height and cover within one growing season after cutting (Haeussler *et al.* 1990). D'Anjou (1990b) reports that thimbleberry grew to 90% (60–100 cm) of its pre-treatment height within 1 year of treatment. Timing does not appear to influence the effectiveness of the treatment. Thimbleberry was cut at four dates throughout the growing season and treatment was ineffective on all the dates. Three years after treatment, the thimbleberry had recovered to a percent cover equalling or exceeding pre-treatment levels.[8]

Research and anecdotal information indicate that **salmonberry** is a rapid sprouter (Roberts 1980; Wagner 1984; D'Anjou 1990b; J. McClarnon, pers. comm., 1990). D'Anjou (1990b) reports that salmonberry achieved 60–90% (up to 1 m) of its pre-treatment height in one growing season. However, there is no consensus on whether the timing of the cut affects salmonberry's ability to sprout. D'Anjou (1990b) states that timing does not "practically" affect salmonberry's growth; Roberts (1980) reports some variation, with late foliar cutting being better; Turpin (pers. comm., 1990) states that salmonberry sprouted less when cut during the June through August period.

None of the studies has tested multiple cuttings of salmonberry, although one operational report suggested that they may be necessary (J. McClarnon, pers. comm., 1990). Preliminary results from one study suggest that cutting for 2 years before harvesting may help reduce salmonberry's competitive ability (J. Zasada, pers. comm., 1990). On-going research on salmonberry's ability to persist and maintain itself in dense thickets should help provide insights into managing it more effectively (Tappeiner *et al.* 1991).

Preliminary results from one study show that manual pulling can reduce **salal** cover. This study and another (Dunsworth 1987b) report that reduced salal cover was correlated with enhanced Douglas-fir growth.

Single cutting treatments can effectively control vegetation on sites occupied by slow-growing ericaceous shrubs such as white-flowered rhododendron, false azalea, and *Vaccinium* spp. For example, white-flowered rhododendron had six sprouts for every stem cut, but each sprout averaged 3 cm in length after 1 year.[9] Brush control may be avoided on these sites if they are promptly site-prepared and planted after logging. However, site preparation treatments must be selected with caution, since disturbance may also cause species shifts and result in the development of vigorous herbaceous communities on some moist sites.

2.4 Manual Cutting of Grasses, Ferns and Herbs

The effectiveness of manual brushing on selected grasses, ferns and herbs is outlined in Table 5. In general, cutting provides only short-term control of competing herbaceous vegetation. Manual cutting only

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[6] Noble-Hearle, G. 1988. Treatment effectiveness checks: brushing and weeding program. B.C. Min. For., Penticton For. Dist., Penticton, B.C. Unpubl. report.

[7] Hanlon, L. 1987b. Efficacy of manual treatment timing on Sitka alder in immature Englemann spruce: interim report. B.C. Min. For., Nelson Region, Nelson, B.C. Unpubl. report. SX86705N.

[8] LePage, P. 1989. Site preparation rate x timing trial for thimbleberry control. Expert Committee on Weeds (ECW). West. Canada Section Meet., Nov. 28–30, Banff, Alta. Res. Report, p. 213. Unpubl. report.

[9] Skakun, A.M. 1990. Regeneration of white-flowered rhododendron (*Rhododendron albiflorum*) after manual cutting on a clearcut site within the ESSFc subzone: first year growth response. Prepared for Assoc. B.C. Prof. Foresters. Unpubl. report.

removes the above-ground portion of the plant and many grass and herb species are able to resprout rapidly from extensive root systems. Consequently, clipping of herbs and grasses may not noticeably benefit crop trees unless treatments are repeated frequently.

TABLE 5. Effectiveness of manual brushing for controlling selected grasses, ferns and herbs

Species	Effectiveness of manual cutting (single treatment only)	Most effective time to cut	Comments
Pinegrass	–resprouts vigorously		–clipping may not significantly benefit conifer seedlings –repeated clipping will control this species
Bluejoint reedgrass	–resprouts vigorously		–repeated cuttings have reduced the vigour of this species
Lady fern	–resprouts vigorously	–mid-summer (July) cutting will provide control only until the following spring	–cutting in June results in regrowth to untreated heights by the end of July –repeated cutting over successive years will reduce vigour
Bracken	–resprouts vigorously	–mid-summer (July) cutting will provide control only until the following spring –for cutting twice in one growing season, the first cut should be made before the frond is fully expanded and the second cut should be made 6 weeks later	–repeated cuttings over successive years have not appeared to reduce vigour –repeated cutting within a growing season may be necessary
Fireweed	–resprouts vigorously	–a cutting during full leaf-out (from late July through August in the southern Interior) provides control only until the following spring	–a major contributor to vegetation press problem –hockey sticks have been used to bend rather than sever stems, reducing the need for retreatment within the same growing season; retreatment will be necessary in the subsequent years –repeated mid-summer cutting over 3 years can reduce height and cover

In herbaceous communities, repeated cuttings over successive years may be necessary. Following cutting in June in the ICH zone, **fireweed, lady fern** and **bracken** were the same height as untreated plants at the end of July (P. Comeau, pers. comm., 1990). **Reedgrass,** lady fern and fireweed are all reduced in vigour with repeated cuttings over successive years. Unpublished research suggests that repeated cutting over 3 successive years reduced fireweed cover and height by approximately 30%, but did not reduce the vigour of bracken (P. Comeau, pers. comm., 1990). Repeated cutting within the same growing season may be necessary to achieve acceptable levels of vegetation control on some sites.

Timing is important for cutting bracken. Haeussler *et al.* (1990) recommend that the first cut should be made before the frond is fully expanded, the second about 6 weeks later. In the southern Interior, cutting fireweed any time after late July gives effective control of this species for the balance of the growing season (P. Comeau, pers. comm., 1990).

Knocking down herbaceous vegetation without severing the stems can improve the light regime for conifer seedlings and reduce problems of physical damage and vegetation press which are common in these communities. To date, this technique has only been tested on fireweed.

3 CROP TREE RESPONSE

The growth response of crop seedlings to brushing is influenced by the age and condition of the conifers and the amount of brush control achieved.

Several studies have found that manual brushing improved crop tree growth (MacLean and Morgan 1983; Petersen and Newton 1985; Bigley 1988; D'Anjou 1989). No long-term studies comparing manually and

chemically released crop trees are available in British Columbia. In northwestern New Brunswick, results showed that manual brushing to control mountain maple did improve the growth of balsam fir (MacLean and Morgan 1983). Both types of treatments increased the volume of the balsam fir, although the herbicide treatments gave a better response (an average 211% increase over the control versus a 64% increase for the manual brushing).

Petersen and Newton (1985) studied the effects of different snowbrush removal treatments on the growth of Douglas-fir in Oregon. Manual brushing gave larger diameters and heights on the Douglas-fir than on the control, and herbicides used on the snowbrush produced even larger volumes. The greatest stem and diameter response was found when all non-crop vegetation (snowbrush and forbs) was controlled using herbicides.

Bigley (1988) found that Douglas-fir saplings released early in the growing season from overtopping red alder responded more favourably to manual release than those saplings manually released mid-way through the growing season. The latter tended to have constant or declining photosynthetic rates. Bigley noted that the saplings were unable to adapt to the sudden change in light conditions later in the growing season, likely because they had shade rather than sun leaves.

To reduce salal cover, D'Anjou tested a variety of treatments. Several, including manual pulling, "enhanced" Douglas-fir growth. Increased growth of Douglas-fir was attributed to improved moisture availability.

Other studies have not found any benefits to crop trees with manual brushing. In southwestern Oregon, Hobbs and Wearstler (1985) used brush saws to remove sclerophyllous brush (canyon live oak and greenleaf manzanita) near ground level at three intensities: total removal, partial removal, and an untreated control. Three years after treatment, the growth rate (basal diameter) of the Douglas-fir was not significantly different from the untreated control as a result of the rapid sprouting of the brush.

In the red alder-shrub complex in Oregon, Roberts (1980) compared total removal of brush by manual cutting to an untreated control. Treatments were conducted over three periods of the year: dormant, early foliar and late foliar. Two years after treatment, the benefits to Douglas-fir height growth were "negligible." In some cases (such as when crop trees were damaged by the brushing treatment or sunscald occurred) impact was negative. Harrington and Wagner (1986) tested a variety of herbicide treatments and a manual cutting treatment for controlling red alder and shrubs. After 3 years, none of the treatments significantly increased Douglas-fir height or stem diameter growth above that of the untreated control.

4 DAMAGE TO CROP TREES

Manual brushing treatments can damage crop seedlings, resulting in reduced survival or growth. Post-treatment damage to crop trees may come from three sources: the tools used to conduct the treatment, sunscald, and falling slash.

There have been many reports of crop tree damage from cutting tools used in manual brushing treatments, especially in heavy brush when the trees are not visible. Estimates of damage to crop trees in the literature range from 19 to 31% (Bernstein 1977; Roberts 1980; Holmsen and Whitehead 1988). Operational treatments damage approximately 20% of the crop trees (R. Whitehead, pers. comm., 1990).

To minimize damage to crop trees, non-cutting tools have been tried. In some areas in the Nelson Region, where fireweed and other herbaceous species impede crop establishment, hockey sticks are used to bend or whack the competing vegetation out of the way. Hockey sticks were selected because it was felt bending or whacking was more effective than cutting for controlling fireweed. The use of hockey sticks may also provide the additional benefit of reducing damage to crop trees (J. Annunziello, pers. comm., 1990; T. Johnston, pers. comm., 1990).

Crop trees may suffer from sunscald or solarization following sudden opening of the canopy by manual methods (Roberts 1980; Bigley 1988; Pendl and D'Anjou 1990). Although few problems have been reported, concerns over potential sunscald problems have been expressed. Damage to seedlings by falling slash is also

of concern (Bernstein 1978; Roberts 1980; Ehrentraut and Branter 1990; Pollack and LePage 1990). Slash depths between 0.3 and 1 m were reported after brushing with chainsaws and brushsaws (Bernstein 1978; Ehrentraut and Branter 1990). Roberts (1977) noted slash was "heavy" following manual brushing but she did not specify its depth. Slash can also be a problem a few years after girdling if stems break (Williams 1987; Pollack and LePage 1990). Heavy slash accumulations may damage seedlings, restrict movement of ungulates and people, and increase fire hazard.

5 COSTS

Statistics for 1989/90 indicate that, on average, manual brushing costs in British Columbia were $541/ha compared with $289/ha for chemical treatments. However, costs for both treatments varied widely between regions (Figure 2). For example, costs for manual treatments ranged from $378/ha in the Cariboo to $819/ha in the Vancouver Forest Region.

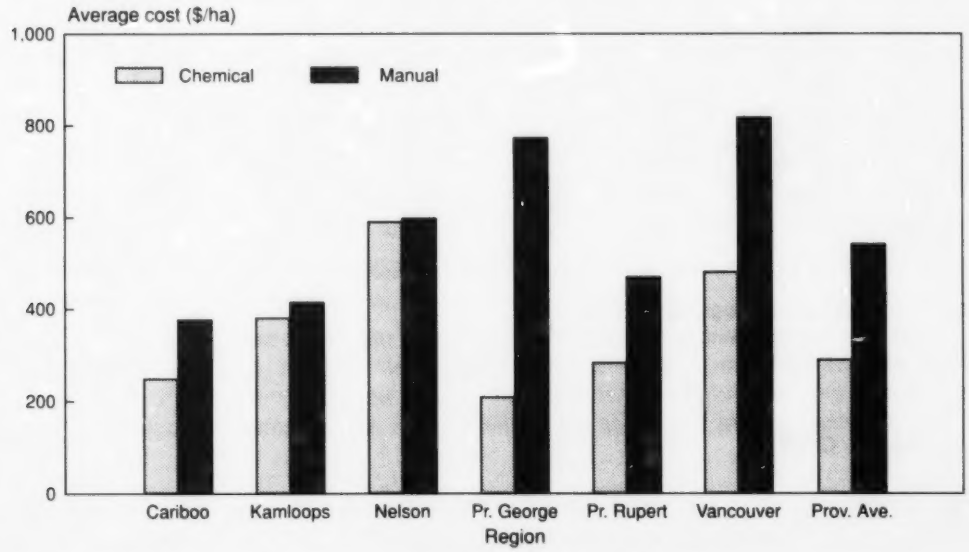

FIGURE 2: Average cost of brushing on Crown forest land in British Columbia, 1989/90.
Source: Silviculture Activity Summary, B.C. Min. For., Silv. Br. 1989/90. Unpublished data.

The use of manual brushing tends to be more common on less brushy sites; the use of herbicides is more common on sites with more severe brush problems. Consequently, these average costs do not provide a true comparison of actual treatment costs.

Comparisons of average costs between manual and chemical treatments within regions showed some interesting trends. In southern regions (Kamloops and Nelson), average costs of manual and chemical treatments were similar ($598/ha vs. $591/ha, respectively). Response to public concern about herbicide use on forest land has resulted in limited use of herbicides in these regions, particularly in the Nelson Region. In addition, the size of blocks being treated is comparatively small. Both factors lead to increased costs for chemical treatments.

For northern and coastal regions (particularly Prince George and Vancouver), manual treatments were considerably more expensive than chemical treatments. In Prince George, manual treatments cost 3.5 times more than chemical treatments ($772/ha compared to $210/ha). These differences are a reflection of the vegetation and areas being treated and the availability of contractors to do the work.

Although southern interior regions (Cariboo, Kamloops and Nelson) accounted for only 30% of the area brushed in 1989/1990, manual brushing was used more frequently in these regions than in other regions (Figure 3). The Prince George, Prince Rupert and Vancouver Forest Regions had the largest brushing programs, and together accounted for 70% of the area brushed in the province.

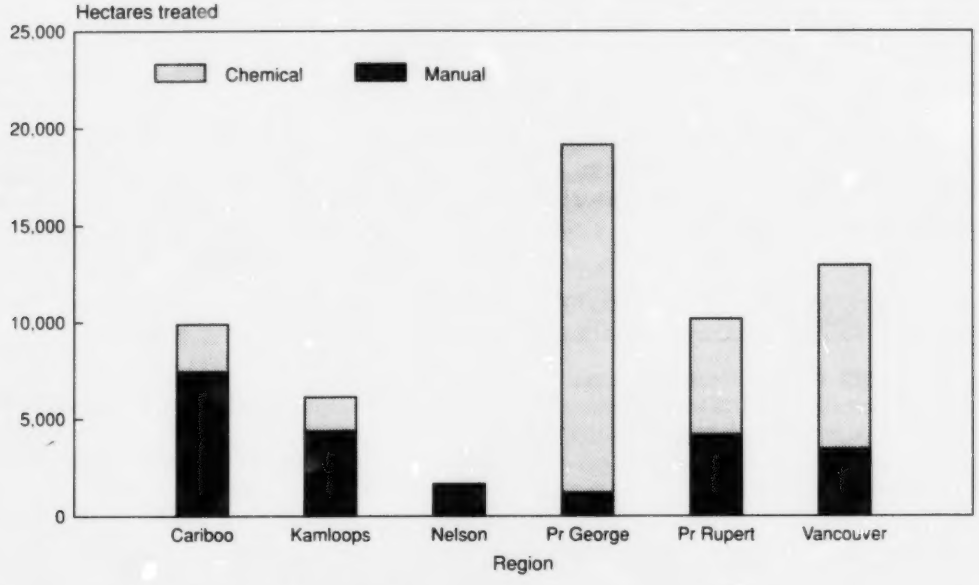

FIGURE 3: Area brushed by region, 1989/90.
Source: Silviculture Activity Summary, B.C. Min. For., Silv. Br. Unpublished data.

5.1 Costs of Manual Cutting

Costs of cutting treatments vary widely and depend on a number of factors including: the composition, size and density of the target species; the relative height of brush and crop trees; the terrain; the availability of contractors; the season; and the specifications of the contract.

The variety of factors involved make it difficult to estimate an average price for manual cutting of a particular species or vegetation complex. Recent reports provide the following costs: $364/ha for salmonberry/woody shrubs in the CWH[10]; $600–$850/ha for woody shrubs and herbaceous species in the ICH (Holmsen and Whitehead 1988); and $548/ha for aspen in Alberta (Ehrentraut and Branter 1990).

Silviculturists across the province gave an even wider range of costs, from $250/ha in the Williams Lake District (G. Chapman, pers. comm., 1990) to $1500/ha in the North Coast District (M. Grainger, pers. comm., 1990).

Another important factor affecting the cost of manual cutting is the cost of retreatment. Costs presented in this report are for individual entries. Multiple entries may be necessary when manual brushing is used, but are less likely with chemical treatments. This increases the relative difference in cost between manual and chemical treatments.

[10] Scagel, R. 1990. Rehabilitation of NSR by underplanting: third growing season results. Third year progress report. B.C. Min. For., Port Alberni District, Port Alberni, B.C. Unpubl. report.

To keep costs as low as possible, some silviculturists wait until the conifers have reached a target height or growth rate so that they have a good chance of getting above the brush with a single treatment (P. Chalifour, pers. comm., 1990; G. McKee, pers. comm., 1990; Perry[11] 1987). The target height and leader growth rates are variable and are largely a matter of the silviculturists' preference. Such a prescription is only appropriate where delaying treatment does not seriously compromise the survival of crop trees. On sites where shrubby or herbaceous vegetation develops rapidly and seriously threatens survival of crop seedlings, manual brushing should be initiated as soon as the vegetation threatens to overtop crop seedlings.

Combining a release treatment with a spacing treatment may also be an economical alternative (Perry[11]; J. Przcezek, pers. comm., 1990). Costs again vary widely, from $300 to $1500/ha (P. Chalifour, pers. comm., 1990; S. Dunn, pers. comm., 1990; R. Enfield, pers. comm., 1990; D. Horn, pers. comm., 1990; J. Perry, pers. comm., 1990).

5.2 Costs of Girdling

Costs of girdling range from $297/ha for red alder (Pollack and LePage 1990) to $440/ha for aspen (Holmsen 1990). Costs of girdling are generally similar to those of hack-and-squirt. Bancroft (1978) found this for controlling red alder. Holmsen (1990) found girdling to be the least expensive of four treatments (girdling, Ezject, Gel Cap, and hack-and-squirt) used to control aspen. Waldron (1961) also reports that two girdling methods (axe, girdling tool) were less expensive than two herbicide treatments (basal spraying with 2,4,5-T, basal frilling with 2,4,5-T).

In 1987, girdling costs ranged from $45–$820/ha in British Columbia, and averaged $375/ha. Costs for hack-and-squirt treatments ranged from $11–$905/ha and averaged $260/ha in 1987.

6 CONSTRAINTS ON THE USE OF MANUAL BRUSHING

Factors that can limit the use of manual brushing are (1) the availability of funds to support manual brushing programs and (2) the availability of trained manpower.

The amount of labour currently available to do manual brushing varies across the province. In the more remote areas of the province (e.g., northern Vancouver Island and the Mid-Coast, Horsefly and Dawson Creek Forest Districts) attracting contractors can be difficult. Any increase in manual brushing activities will require recruiting additional labour to complete this work, or improving on the efficiency of existing labour.

7 RESEARCH NEEDS

Additional information is required to help foresters improve the effectiveness of manual brushing investments. Specific research needs include the following:

- Data on the efficacy of manual brushing are required. Much of what is presently known is anecdotal and incomplete. Specific research needs include:
  - (a) the effects of age of crop tree, timing, height of cut, treatment radius around crop trees, multiple treatments, and site factors on treatment efficacy and crop tree response;
  - (b) the necessity of repeated treatments, the length of the retreatment interval, and the required frequency of retreatment;
  - (c) information on recovery rates (height growth, per cent cover) of target species; and
  - (d) the effects of pre-harvest treatments.
- Preliminary information shows girdling can be effective for controlling some hardwood species, particularly red alder and aspen. Cottonwood and birch also appear to be good candidates for girdling. However, many questions remain. Research needs include:

[11] Perry, J. 1987. An assessment of manual brush control in the Cariboo Forest Region. B.C. Min. For., Cariboo Region, Williams Lake, B.C. Unpubl. report.

(a) the effects of timing and height of the girdle on the efficacy of the treatment;

(b) the length of time that different species take to die after girdling;

(c) the time required between pre-harvest hardwood girdling and the harvest of coniferous crops;

(d) the effects of overstorey removal on understorey vegetation; and

(e) slash problems resulting from girdling.

- Research on the costs of manual brushing, especially as compared to that of other treatments, is needed. Administrative and pesticide appeal costs should be included, to provide a more accurate picture of the true costs of a variety of treatments.
- Assessment of damage to conifers from manual and chemical brushing is required. Damage from the brushing tool is a major concern, especially where the seedlings are difficult to see. Damage from sunscald, slash and animals also requires further study. Demonstration sites and forums for exchanging expertise on manual brushing should be encouraged.
- Brush problems appear to be concentrated predominantly in the SBS, ICH, ESSF and CWH zones. Priority for research should be given to problem complexes within these zones. Species within these zones that should receive priority for research include fireweed, thimbleberry, black twinberry, bracken, Sitka alder, *Vaccinium* spp., reedgrass, red alder, salmonberry, bigleaf maple, aspen and birch.

In addition to the above research needs for manual brushing, many silviculturists and researchers from around the province have identified several basic vegetation management research needs that have implications for manual brushing. Examples include: better autecological information; decision-making tools to identify when non-crop vegetation is impeding conifer growth; investigation into the beneficial effects of non-crop vegetation and into the effects of non-crop vegetation on non-timber resources; and information on alternative non-chemical vegetation management techniques. For a more complete discussion of vegetation management research requirements, see Kimmins and Comeau (1990).

8 CONCLUSION

More research on manual brushing is needed. With the increased commitment to improving the survival and growth of young forests in British Columbia, the increased pressure to reduce herbicide use on forest land, and the need to treat buffer strips, it is likely that the use of non-chemical methods of brushing will grow. Manual brushing will remain an important non-chemical brushing alternative, although the use of other treatments (e.g., livestock browsing and biological controls) may also increase as experience with their use increases.

Improving on the effectiveness of manual brushing and reducing its total cost are priorities. Current knowledge of the effectiveness of manual brushing is largely anecdotal. The effects of multiple treatments and the optimum time to manually brush to reduce sprouting are unknown for most non-crop species. The optimum timing of the treatment to provide the maximum benefit to crop trees is also unknown.

APPENDIX 1. A summary of the effectiveness of manual brushing treatments in selected vegetation complexes

Cottonwood 14
Cottonwood-alder 14
Bigleaf maple 15
Mixed hardwoods 16
Aspen 17
Boreal poplar 18
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Red alder 20
Salmonberry 23
Salal 24
Mixed shrub 25
Ericaceous shrub 26
Dry alder 27
Wet alder 28
Dry shrub 28
Willow 28
Pinegrass 29
Reedgrass 29
Fern 29
Bracken 29
Fireweed 29
Subalpine herb 30
Introduced grasses 30

This section summarizes information on the effectiveness of manual brushing in each of the major species complexes, as described by Newton and Comeau (1989) found in British Columbia. A map outlining the biogeoclimatic zones of British Columbia is found in Appendix 2.

Cottonwood

Introduction

The cottonwood complex is found on floodplains throughout the interior of the province, in the IDF, ICH, MS, SBS and BWBS zones. Black cottonwood, black twinberry, elderberry, thimbleberry, mountain alder, Sitka alder, bluejoint and nodding wood-reed are the major species in this complex.

Research in British Columbia/Discussion

Cottonwood is known to be a vigorous sprouter (Haeussler *et al.* 1990).

Cottonwood sprouting was examined at a trial in the Kootenay Lake District.[1] Two rates of hexazinone (applied with spot guns), a manual cutting (chainsaw) treatment, and a control were compared for controlling cottonwood and thimbleberry. After one growing season, the cottonwood in the manual treatment had an average of 25 sprouts per stem cut. Following the herbicide treatments, defoliation was 80–90%, approximately half the stems were killed and sprouting was virtually nil. Thimbleberry height and cover increased in all the plots except one in the herbicide treatments.

As this study shows, if one species in the complex is effectively controlled (i.e., cottonwood), another species (i.e., thimbleberry) may replace it as a vegetation competition problem.

Cottonwood-Alder

Introduction

The cottonwood-alder complex is located on the floodplains in coastal areas of the province, in the CDF and CWH zones. Major species found in this complex include black cottonwood, red alder, salmonberry, red-osier dogwood, devil's club, red elderberry and thimbleberry. Its location on coastal floodplains and the presence of cottonwood distinguishes it from the red alder-shrub complex.

Literature Review

Cottonwood sprouts vigorously after cutting. Interest in managing cottonwood production in this complex is growing (see McLennan 1990).

Operational Experience

Cottonwood may sprout 1–2 m during the same growing season of cutting, with 5–10 sprouts for every stem cut (B. D'Anjou, pers. comm., 1990). In the North Coast District, M. Grainger is trying to grow cottonwood from coppice, but the red alder is outcompeting it (pers. comm., 1990). Skeena Cellulose has tried planting western redcedar and spruce under a partially closed cottonwood canopy to see if it gives any protection from weevils. So far the spruce seem to be better off, but the cedar is being browsed (A. MacDonald, pers. comm., 1990).

Discussion

Many of the species found in this complex are also found in the red alder-shrub complex, and much of the information found there would be applicable to this complex as well. Growth rates on these rich, alluvial sites are very high, and the sprouting ability of non-crop vegetation would be expected to be very high. Cottonwood is considered a crop species in some areas. It is also being used as a nurse crop to protect spruce from weevil attack and to reduce effects of competing shrubs.

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[1] Hanlon, L. 1987a. Efficacy testing of Velpar-L (Hexazinone) for brushing and weeding spruce plantation: interim report. B.C. Min. For., Nelson Region, Nelson, B.C. Unpubl. report. SX86704N.

Bigleaf Maple

Introduction

The bigleaf maple complex is found on low-elevation moist sites in the CDF and CWH. When the complex is disturbed by logging activities, coppicing results in multi-stemmed clumps of bigleaf maple that can cover large areas.

Literature Review

Roberts (1980) found that cutting bigleaf maple in the late foliar period (mid- to late summer) in Washington and Oregon produced the shortest and fewest sprouts. After two growing seasons, maple was 2.7 m tall and there were three sprouts for every stem cut.

Wagner (1987) compared several manual and herbicide treatments for controlling bigleaf maple sprout clumps in coastal Oregon. Three timings of manual cutting were tested: dormant, early foliar and late foliar. First-year results showed that manual cutting reduced crown volume about 43%, and there was no significant difference between the three times of cutting. However, crown volume was lowest with the August timing. All of the clumps that were manually cut sprouted, and regained more than half their pre-treatment crown volume and 75% of their pre-treatment height. In general, herbicide treatments were more effective.

Recent research in Oregon is focussing on modelling the space occupancy of bigleaf maple following harvesting. Bigleaf maple's reproductive strategy (shoots and buds) is also being examined (T. Harrington, pers. comm., 1990; J. Zasada, pers. comm., 1990).

Research in British Columbia

A trial to investigate manual and chemical control of bigleaf maple was undertaken near Duncan, B.C.[2] Manual cutting during early September resulted in vigorous sprouting. Two years after cutting, the height and average number of sprouts were very similar between the control and the manual cutting. Glyphosate (6% solution), on the other hand, significantly reduced height and the number of sprouts.

Operational Experience

Silviculturists in the Campbell River District have been trying to control bigleaf maple by cutting and enclosing the stump in heavy black plastic bags. This time-consuming process involves double-bagging the stump and stapling the bag below the root collar. All light must be eliminated or the resilient maple will form sprouts under the bag. While some limited success is being experienced, tears in the bags are proving to be a problem (S. Dunn, pers. comm., 1990).

Another alternative being tried is to get all of the maple to grow on one stem, rather than in a clump, to reduce the competition in the canopy (S. Dunn, pers. comm., 1990; S. McRuer, pers. comm., 1990). Its success to date is unknown.

Post-harvest girdling using the Little Beaver® has proven unsuccessful to date (B. Granger, pers. comm., 1990).

Discussion

Operational and research experience indicate that bigleaf maple sprouts vigorously after being cut or disturbed by logging. The crowns of bigleaf clumps may be reduced by half after one growing season when manually cut (Wagner 1987), but sprouts may range in size from 2 to 3 m after two growing seasons, (Roberts 1980; Boateng and Ackerman[3]), There may be up to 50 stems per stump.[4]

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[2] Boateng, J. and G. Ackerman. 1988. Maple coppice trial. Expert Committee on Weeds (ECW). Research report. West. Canada Section Meet. Nov. 29–Dec. 1, 1987, Winnipeg, Man. Unpubl. report, p. 192.

[3] Boateng, J. and G. Ackerman. 1988. Maple coppice trial. Expert Committee on Weeds (ECW). Research report. West. Canada Section Meet. Nov. 29–Dec. 1, 1987, Winnipeg, Man. Unpubl. report, p. 192.

[4] *Ibid.*

A variety of post-harvesting manual treatments have been tried, but so far none have been successful. These include cutting, enclosing stumps in black plastic bags to eliminate light, and girdling. Where there are large numbers of shoots, girdling is not likely to be feasible.

Preventative, pre-harvest measures may be more successful than post-harvest treatments. So far, little attention has been paid to pre-harvest treatments and on-going research should provide useful information on the pre- and post-harvest biology and growth of bigleaf maple. Greater care during logging to minimize disturbance to existing trees, and pre-harvest cutting, girdling or herbicide treatments may be useful for controlling the species.

Mixed Hardwoods

Introduction

This complex occurs on a range of sites in the Interior, in the IDF, ICH, MS, SBS and BWBS zones. The major species include trembling aspen, cottonwood, paper birch, willow, mountain alder and Sitka alder. (Pure stands of either aspen or willow are discussed separately in other sections below).

Research in British Columbia

The Cariboo Region reported mixed results from the manual cutting of hardwoods (willow, aspen, alder, birch, cottonwood).[5] On four of the seven sites examined, manual brushing was not considered successful because of heavy brush competition, deep slash covering small seedlings, or pre-treatment rodent damage.

In the Horsefly District, four treatments were compared: a control, felling all deciduous species, cutting to remove overtopping vegetation, and girdling.[6] Weevil damage was observed on conifers in all treatments except the control, where leaders were not visible. In the two cutting treatments, browsing by hares was considered to be the main factor controlling sprouting of cottonwood and willow. Conifers were not browsed in the areas that had been cut, but some browsing was noted in the girdled plot and the control. There was no basal sprouting of the girdled cottonwood.

Another trial investigated the effects of four manual treatment timings (late May, late June, early August, early September) on the sprouting ability of Sitka alder and willow in the Kootenay Lake District.[7] After one growing season, August and September cutting was more effective at reducing the per cent cover of both species, although the willow was less affected than the Sitka alder. Reductions in the per cent cover of willow were 14.1 and 16.9% for the August and September timings, compared to reductions of 46.1 and 42.6% for the Sitka alder.

West Fraser Mills, on a site in the Quesnel District, compared the effects of a manual cutting treatment to those of three herbicide treatments for controlling aspen, willow and birch. First-year results show that with the manual cutting, willow was the most vigorous sprouter of the three species (D. Routledge, pers. comm., 1990).

In another study, the efficacy of girdling aspen, birch, cottonwood, alder and willow at three phenological stages (before leaf-out, during leaf-out and after leaf-out) was tested (J. Perry, pers. comm., 1990). The preliminary results show that girdling is effective on aspen and cottonwood, is difficult to perform on birch because the stems are not always circular, and is not effective on Sitka alder or willow clumps.

Operational Experience

Many silviculturists in the Interior have manually brushed in this complex. They report vigorous sprouting of several species, particularly aspen, cottonwood and willow. Five-fold increases in the number of aspen stems after cutting were reported (S. Clayton-Brown, pers. comm., 1990) and sprout growth of 1.5 m in height

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[5] Perry, J. 1987. An assessment of manual brush control in the Cariboo Forest Region. B.C. Min. For., Cariboo Region, Williams Lake, B.C. Unpubl. report.

[6] Perry, J. 1988. Manual conifer release of spruce final report. B.C. Min. For., Silv. Br., Victoria, B.C. SX84404C. Unpubl. report.

[7] Hanlon, L. 1987b. Efficacy of manual treatment timing on Sitka alder in immature Englemann spruce: interim report. B.C. Min. For., Nelson Region, Nelson, B.C. Unpubl. report. SX86705N.

was noted (P. Chalifour, pers. comm., 1990). Reports of cottonwood sprouting within a few weeks and growing 2 or 3 m in one growing season, were noted (P. Chalifour, pers. comm., 1990; J. Wright, pers. comm., 1990). Similarly, willow cut in July was reported to grow 2 m by September (E. Nedokus, pers. comm., 1990). Birch girdled at breast height also had significant sprouting (R. Enfield, pers. comm., 1990).

With respect to the timing of the treatment, many silviculturists have found that cutting between mid-June and mid-August seems to be most effective (J. Annunziello, pers. comm., 1990; J. Perry, pers. comm., 1990; A. Pollard, pers. comm., 1990; D. Routledge, pers. comm., 1990). However, not all silviculturists have found that timing makes a difference (P. Lishman, pers. comm., 1990).

Waiting until the crop trees are well established before attempting to manually brush, or combining a manual brushing with a spacing project, is common in this complex. Girdling larger diameter stems (generally 5 cm diameter or more) is also growing in popularity. Aspen, cottonwood and birch are the most common species girdled. In the Robson Valley District, these species have been girdled during May and have not sprouted (D. Salayka, pers. comm., 1990).

Many silviculturists do not try to remove all the hardwoods from the site, since they feel the hardwoods, especially Sitka alder, contribute to long-term site productivity (R. Enfield, pers. comm., 1990; J. Przcezek, pers. comm., 1990). Forage for animal browse, especially willow for moose browse, was also cited as a reason for leaving some hardwoods (R. Enfield, pers. comm., 1990; J. Perry, pers. comm., 1990; P. Veltmeyer, pers. comm., 1990).

Discussion

This complex is common in the Interior and occurs on a wide range of sites. Research and anecdotal experience show that, after cutting, all the major species in this complex are vigorous sprouters. Aspen, cottonwood and willow are especially vigorous, and may sprout from 1.5 to 3 m in one growing season. Cutting between mid-June and mid-August seems to help reduce sprouting. Girdling is becoming more common, particularly on stems larger than 5 cm in diameter. Aspen and cottonwood may be effectively controlled with girdling, but reports on birch are mixed. Girdling is not effective on Sitka alder and willow, primarily because of the species' clumpy growth habit and small stem size, and the large number of stems requiring treatment.

Leaving some hardwoods on a site is also gaining acceptance. Concerns about long-term site productivity, wildlife forage and diversity in the forest were all cited as reasons for this. The role of hardwoods in long-term site productivity is unclear, but Sitka alder in particular is believed to be beneficial at low densities. Willow is an important forage species for moose. It has also been shown that providing forage for hares, by cutting willow and cottonwood to produce sprouts, may reduce damage to conifers in areas of high hare populations.

Further information on aspen, willow and Sitka alder is provided in sections dealing with these complexes.

Aspen

Introduction

Pure stands of aspen are found across a range of sites in the IDF, ICH, MS, SBS and BWBS zones. Aspen is considered a crop species in the Peace River area and zones in other parts of British Columbia.

Literature Review

Considerable research has been done on the effects of manual cutting and girdling aspen, and this is reviewed in Haeussler *et al.* (1990). Bancroft (1989) also summarizes information on the response of aspen to pre-harvest stem treatments. Aspen suckers profusely following cutting, usually producing more than twice as many suckers as girdled aspen (Schier 1978). Girdling can therefore be effective for controlling aspen (Bancroft 1989), though aspen may take between 1 and 3 years to die following treatment.

Research in British Columbia

One study compared the efficacy of three timings of manual cutting (November, June and July) and two application rates of hexazinone gridballs on aspen suckering.[8] There were 30% fewer coppices and sucker shoots produced from the June manual cutting than from the other cutting dates. The regrowth height was similar between the June and July treatment dates, but the November cutting was 48% taller. Effectiveness of hexazinone treatments was influenced by depth of surface organic material. Where surface organic layers were thin, hexazinone gave effective control of aspen. Hexazinone treatments were ineffective where soil surface organic horizons were 8 cm deep.

Another project was recently initiated in the Prince Rupert Region.[9] A manual cutting treatment (mid-June) is being compared to four different times of girdling (June 1989, August 1989, October 1989 and April 1990). Second-year results show that manual cutting is not effective for controlling aspen, but girdling is showing some promise. Of the four times of girdling, the June treatment gave the highest proportion of dead or dying aspen (75% compared to 20, 30 and 20%, for the August, October and April treatments, respectively). However, the June treatment also has the tallest and greatest number of sprouts, although these are only 28 cm for the average tallest sprouts and 5 sprouts per stem. No root suckers were observed following any of the girdling treatments.

Operational Experience

Operational experience with girdling or cutting aspen is limited. Girdling has been tried operationally in the Fort Nelson District, but success was poor and the contractors did not like doing it (D. Horn, pers. comm., 1990).

Opinions on when to cut aspen vary. In the Quesnel District, it is reportedly best to cut aspen in late July or August to minimize sprouting (G. McKee, pers. comm., 1990). In the Terrace area, however, another silviculturist indicated that cutting aspen late in the year (dormant) reduced suckering (F. Philpot, pers. comm., 1990). Site conditions may also affect aspen's suckering ability. On very dry to dry (xeric) sites in the Cariboo Region, aspen does not usually sucker (J. Perry, pers. comm., 1990).

Discussion

Aspen's ability to sucker after cutting limits the usefulness of manual cutting, except possibly on very dry to dry (xeric) sites. Girdling may be the most effective strategy for controlling aspen: it does not promote root suckering, although the aspen may still sprout. Both pre- and post-harvest girdling show promise. With pre-harvest girdling, the most effective timing between treatment and harvest is unknown. Preliminary results show that girdling in June in the Bulkley, Morice and Lakes Districts may be the most effective time.

Boreal Poplar

Introduction/Discussion

This complex occurs on fresh to moist sites in the SBS and BWBS zones in northern British Columbia. The two main species in this complex are aspen and cottonwood.

Results from research on both the main species in this complex are summarized elsewhere in this report. Both cottonwood and aspen are discussed as the main species in their respective complexes (see "Cottonwood" and "Aspen", pages 14 and 17, respectively) and as components in another complex (see "Mixed Hardwood", page 16).

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[8] Herring, L. 1984. Conifer release with manual cutting and hexazinone gridballs. Expert Committee on Weeds (ECW). West. Canada Section Meet., Dec. 6–8, Winnipeg, Man. Res. Report, p. 262. Unpubl. report.

[9] Coates, D. and F. Newhouse. 1990. The effect of girdling and manual cutting on the sprouting and suckering capacity of young aspen in the SBS zone of the Prince Rupert Region: first year progress report. B.C. Min. For., Prince Rupert Region, Smithers, B.C. Unpubl. report.

Red Alder-shrub

Introduction

This complex is found on fresh to wet sites in the CDF and CWH zones, some of the best sites for conifer growth in British Columbia. Major species common in this complex include red alder, vine maple, thimbleberry, salmonberry, red elderberry, devil's club, currant, and swordfern. Many of these species can seriously impede conifer growth.

The importance of these sites for conifer growth and their proximity to researchers means that these complexes have received more attention than the others described in this report. Manual control of red alder (through both cutting and girdling) has had enough research to merit a separate discussion. Accordingly, the red alder-shrub complex review will be followed by a discussion on the manual cutting and girdling of red alder.

Literature Review

Roberts (1980) was the first to document the effectiveness of manual brushing in the red alder-shrub complex in northwest Oregon and southwest Washington. Manual cutting treatments were conducted during the dormant (March), early foliar (June) and late foliar (August/September) periods. Second-year results showed that nearly all species sprouted vigorously after cutting. When measured 18–19 months after cutting, average vegetation height for the dormant season treatment was the highest (1.6 m) of the three timings, compared to 1.3 m for both the early foliar and late foliar cutting treatments.

Following dormant season cutting, cover returned to near pre-treatment levels after two growing seasons. Following early and late foliar cutting, cover returned to 85% of pre-treatment levels. There were 2–11 sprouts per cut stem.

Wagner (1984) reported that within 2 years of manual cutting, brush encroachment was 32% greater than at pre-treatment levels. However, brush encroachment in the control had increased 68% (more than twice as much as the increase from the manual cutting) within the same time period.

Research in British Columbia

Manual cutting was included for comparative purposes in several trials in the Chilliwack Valley and on Vancouver Island. One project specifically investigated the effect of manual treatment timing on non-crop vegetation in the red alder-shrub complex (D'Anjou 1990a). His results were summarized and recently published as FRDA Report 135 (D'Anjou 1990b). Most of the species sampled sprouted vigorously following manual cutting. After one growing season, height and cover increased by more than 50% over pre-treatment levels. Cutting occurred at various times throughout the growing season, but timing did not affect the sprouting ability of the species studied (except red alder, which is discussed below).

In a trial near Port Alberni, sprouting of the understorey 2 years after brushing was "abundant" in the manual treatment.[10] Herbicides were found to be more effective in that trial for controlling both height and cover of understorey species.

Operational Experience

Many silviculturists believed species in this complex were vigorous sprouters, and that for conifer establishment, brushing treatments were required frequently. The definition of "frequently" ranged from two treatments per growing season to treatments every 2 years. This range likely reflects the age and composition of the stand, and the variability of individuals' experience with vegetation management in general, and manual brushing in particular.

[10] Scagel, R. 1990. Rehabilitation of NSR by underplanting: third growing season results. Third year progress report. B.C. Min. For., Port Alberni District, Port Alberni, B.C. Unpubl. report.

Discussion

Reports to date advocate that most species in this complex recover so quickly that manual brushing provides at best a short period (i.e., 1–2 years) of release for conifers (Roberts 1980; Wagner 1984; D'Anjou 1990a; D'Anjou 1990b).

Results to date do not indicate any pronounced effect of time of cutting. However, timing of treatments has not been well tested.

Red Alder

Introduction

Several reports document the responses of red alder to cutting or girdling treatments. They also describe its sprouting characteristics and make recommendations on cutting (Harrington 1984; Hoyer and Belz 1984; DeBell and Turpin 1989; Beese[11]) or on girdling (Pendl and D'Anjou 1990; Pollack and LePage 1990; Weaver 1983; Williams 1987; Banner;[12] Beese;[13] Courtin;[14] Eastwood;[15] Hedin;[16] Scagel[17]). Information will be presented first on manual cutting, and then on girdling.

Manual Cutting of Red Alder

Literature Review

Most of the literature on manual cutting of red alder comes from Oregon and Washington. Harrington (1984) was the first to document the factors influencing the initial sprouting of red alder in Washington, and most subsequent work has been based on her results. She found less sprouting when alder was cut during the growing season (July and September compared to January and May) to heights of 10 cm or less. She also found that sprout vigour declined with age, and stands 10 years or older did not sprout vigorously. The angle of cut also affected mortality: stumps with a level surface had the greatest mortality and were least likely to sprout; stumps cut with a surface facing south or west had the least mortality and were most likely to sprout. Harrington speculated that moisture and temperature on the cut surface may influence the activity of decay organisms, hence water ponding on a level surface may increase decay. South- and west-facing cuts would not retain water, and would benefit from higher temperatures caused by increased solar radiation.

To reduce sprouting, Harrington (1984) recommends the following: (1) cut during the growing season; (2) cut stumps 10 cm or lower; (3) make a level cut; and (4) if feasible, delay cutting until trees are 10 years or older.

Hoyer and Belz (1984), also working in Washington, investigated the effect of time of cutting on red alder sprouting. Level cuts were made at 30 cm on alder ranging from 3 to 10 cm diameter. Trends indicated that when stems were cut any time between April and late August, the number of stems with live sprouts was 20% or less, with the lowest number occurring when cut in mid-July (10%). The number of stems with live sprouts increased to 40% and greater at other times of the year. However, these results were variable, and the authors said that the treatment appeared to be most effective when alder was cut during the July through mid-August period.

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[11] Beese, W.J. 1985. Manual alder control: a review with recommendations. Presentation to the MacMillan Bloedel Annual Foresters Meet., Jan. 17–18, Qualicum, B.C. Unpubl. report.

[12] Banner, A. 1988. Selective versus complete girdling of red alder stands on a coastal slope near Prince Rupert, B.C.: response of understorey vegetation and conifer regeneration. Working plan. B.C. Min. For., Prince Rupert For. Reg., Smithers, B.C. Unpubl. report.

[13] Beese, W.J. 1985. Manual alder control: a review with recommendations. Presentation to the MacMillan Bloedel Annual Foresters Meet., Jan. 17–18, Qualicum, B.C. Unpubl. report.

[14] Courtin, P. 1989. Underplanting followed by overstorey removal for the conversion of deciduous stands: revised working plan. B.C. Min. For., Res. Br., Victoria, B.C. Unpubl. report. FRDA 2.36.

[15] Eastwood, J. 1985. Assessment of alder girdling operations final report. B.C. Min. For., Silv. Br., Victoria, B.C. Unpubl. report. SX84708.

[16] Hedin, I. 1983. A comparison of productivity of girdling and hack and squirt techniques in conifer release. FERIC, Vancouver, B.C. Interim Report IR-383-2. Unpubl. report.

[17] Scagel, R. 1990. Rehabilitation of NSR by underplanting: third growing season results. Third year progress report. B.C. Min. For., Port Alberni District, Port Alberni, B.C. Unpubl. report.

In another study, information on cutting alder was collected from divisional foresters working with MacMillan Bloedel in coastal British Columbia.[18] These results, coupled with a review of the literature, led the researcher to modify Harrington's recommendations. He recommended that, for coastal British Columbia cutting be conducted during July through September.

DeBell and Turpin (1989), interested in developing management prescriptions based on Harrington's work, initiated a project in the Siuslaw National Forest in coastal Oregon. Some results confirmed Harrington's work, such as time of cutting and age of alder. The authors recommend that June and July are the best time to cut red alder. Cutting in May, August and September resulted in mortality of 88, 70 and 22%, respectively. Height growth and the number of sprouts were the lowest following cutting in June and July. Younger alder was also found to be more vigorous than older alder: stumps of 4-year-old alder had higher survival and taller sprouts than 6- to 10-year-old trees. However, height and angle of cutting had little effect on sprouting.

Guidelines were developed from these findings, and have been used successfully on many federal and state lands in Oregon. These guidelines were also the first to explicitly recognize that location would influence alder phenology and that scheduling should account for these differences. They recommend that: (1) cutting should be scheduled 8–10 weeks after bud break and should cease about 8 weeks later (late May to late July for Siuslaw National Forest); (2) cutting should be delayed until trees are at least 5 years old and, in general, the oldest trees should be cut first to minimize damage to residual conifers; and (3) stump height should be no greater than 20 cm.

Research in British Columbia

Pendl and D'Anjou (1990) recently completed a project investigating the effect of manual treatment timing on red alder regrowth and conifer response at Okeover Inlet, near Powell River, on the south coast of British Columbia They found that alder sprouting vigour decreased if stems were cut later in the growing season. In fact, the 4- to 5-year-old alder had 95–97% mortality when cut low to the ground in August or early September. D'Anjou also noted that this was a dry site for alder, and speculated that the alder may already have been stressed from droughty conditions when cut (B. D'Anjou, pers. comm., 1990).

Dunsworth (1987a) noted vigorous sprouting of alder when it was cut in late September, but he did not report the age of the alder when it was cut or the height of the cut. Sprouts were up to 2 m tall, and the number of stems had increased 3–6 times within 1 year of treatment.

Bigley (1988) found that although mid- to late-summer might be the best time to reduce sprouting of red alder physiologically, it might also be the most stressful time to release Douglas-fir.

Operational Experience

A number of silviculturists reported problems controlling alder sprouting, and noted that they expected to be retreating alder every 2 years. However, they were not questioned on the specifics of timing, age of stems, and other factors known to influence sprouting characteristics.

Discussion

Results of the research on manual cutting of red alder show that at least three factors influence treatment efficacy: age of the alder, timing, and height of the cut. A prescription developed for Siuslaw National Forest is reported to have worked well for the last three growing seasons (DeBell and Turpin 1989). While it is likely, but not certain, that the age of the alder (at least 5 years old) and height of the cut (20 cm or less) will be the same in British Columbia, refinements on the treatment timing may be necessary. DeBell and Turpin suggest scheduling cutting for a window beginning 8–10 weeks after bud break and ending about 8 weeks later. Pendl and D'Anjou (1990), on the south coast of British Columbia, found that cutting during late August or early September gave effective control of red alder. Trials and local knowledge of alder bud break are required before this prescription is extended to other areas of the province. Site factors may also be important to sprouting and require further investigation.

[18] Beese, W.J. 1985. Manual alder control: a review with recommendations. Presentation to the MacMillan Bloedel Annual Foresters Meet., Jan. 17–18, Qualicum, B.C. Unpubl. report.

Girdling Red Alder

Literature Review/Research in British Columbia

Weaver (1983) found that all red alder properly girdled using a Vredenburg girdling tool were dead by the end of the second growing season. The trial was conducted during June, to coincide with active sap flow. Five per cent of the trees were missed or had incomplete girdles.

Mortality of girdled red alder stems was found to range from 16 to 100% after 3 years.[19] The variation was attributed to the time of girdling, rather than to the method, as all methods (sandviks, saws and Vredenburg girdling tools were not tested) produced equally effective results. After 3 years, all trees girdled during January, February, March, April, August, September and October were dead. No girdling was done in November and December. However, during May, June and July, mortality varied from 14 to 99%. The alder are vigorous during this time of active growth and sap flow, and bridging of girdles was common. Eastwood noted that the quality of the girdle affected bridging, and that special care was needed to ensure effectiveness of the treatment during this time. She suggested that cuts extend slightly into the wood to ensure the cambium is severed. Weaver (1983) mentions that June is thought to be the best time to girdle red alder because the sap flow makes the procedure less time consuming and physically easier to carry out.

In addition to recounting Weaver's success with girdling, Beese[20] reported success (96% kill) at another MacMillan Bloedel division on Vancouver Island. He noted that alder appears to take a year to die, and that this slow release can benefit conifers. He warns, however, that it can be a disadvantage with alder seed tree control, as a stress crop of seed may be produced.

Bigley (1988) girdled red alder near Vancouver, and suggested this treatment might be better for the crop trees than treatments that quickly open up the stand. He suggests that the slow release allows the conifers beneath the canopy to adjust physiologically and morphologically to the changing light levels.

Four other trials are currently under way on girdling red alder in British Columbia, but results are only available from one of them. Girdling alder was one of the treatments tested as part of the Salvus stand conversion study on the Skeena River floodplains. A Vredenburg girdler was used to girdle stems from 6 to 15 cm in diameter, and a chain-type girdler was used on larger stems. Work was conducted in July 1987 and, by fall 1989, girdling had defoliated or killed most alder stems. Cambial bridging was less than 5%. By May 1990, most stems had broken off at the point of treatment, resulting in a significant slash problem. Travel through the plots is difficult and dangerous, and damage to seedlings is expected. In addition, the understorey has vastly increased in vigour, and the three planted coniferous species are not expected to survive (Pollack and LePage 1990).

On the Queen Charlotte Islands, an SX trial is set up to evaluate and assess the growth and survival of Sitka spruce seedlings that were underplanted below chainsaw-girdled red alder. The trial is due for re-assessment, but preliminary results also show substantial alder breakage and vigorous grass growth in the plots (D. Williams, pers. com., Nov. 1990).

In a study on Tuck Inlet near Prince Rupert, girdling is being used to remove the alder overstorey (A. Banner, pers. comm., 1990). This study compared partial (about 50%) and complete removal of the overstorey, and manual brushing of understorey vegetation. The study will monitor succession and evaluate the impact of these treatments on natural and underplanted conifers.[21] Girdling, carried out in January 1988,[22] appeared to be effective, although some stems were still bridging and it took a couple of years for the alder to die.

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[19] Eastwood, J. 1985. Assessment of alder girdling operations final report. B.C. Min. For., Silv. Br., Victoria, B.C. Unpubl. report. SX84708.

[20] Beese, W.J. 1985. Manual alder control: a review with recommendations. Presentation to the MacMillan Bloedel Annual Foresters Meet., Jan. 17–18, Qualicum, B.C. Unpubl. report.

[21] Banner, A. 1988. Selective versus complete girdling of red alder stands on a coastal slope near Prince Rupert, B.C.: response of understorey vegetation and conifer regeneration. Working plan. B.C. Min. For., Prince Rupert For. Reg., Smithers, B.C. Unpubl. report.

[22] Banner, A. 1989. Selective versus complete girdling of red alder stands on a coastal slope near Prince Rupert, B.C.: response of understorey vegetation and conifer regeneration. First year progress report. B.C. Min. For., Prince Rupert For. Reg., Smithers, B.C. Unpubl. report.

Interim results from another trial indicate that girdling of trees in the 4–16 cm diameter range can be done more rapidly than can hack-and-squirt treatments.[23] For trees larger than 16 cm diameter, hack-and-squirt treatments could be applied more rapidly than girdling.

Operational Experience

Coastal silviculturists have had mixed success with girdling red alder. In the Campbell River trial, three growing seasons passed before the alder died, and there is concern that this might allow the alder two seasons for stress crop seed production (S. Dunn, pers. comm., 1990). MacMillan Bloedel foresters rated the effectiveness of girdling alder from 6 to 9, on a scale from 1 to 10 (W. Beese, pers. comm., 1990). Others felt confident in its effectiveness, particularly on larger stems (J. McClarnon, pers. comm., 1990; S. McRuer, pers. comm., 1990; C. van Hemmen, pers. comm., 1990; D. Williams, pers. comm., 1990; B. Wilson, pers. comm., 1990).

Discussion

Information from research and operational girdling treatments of red alder show that this treatment has mixed success. Reports on the length of time it takes alder to die vary from 1 to 3 years (Beese;[24] Dunn, pers. comm., 1990; B. Wilson, pers. comm., 1990) and reports on the best time to girdle are conflicting. Bridging is apparently common if red alder is girdled during active sap flow unless workmanship is flawless, although excellent results without a bridging problem have been attained at other times of the year.[25] On the other hand, Weaver (1983) intentionally girdled during active sap flow, stating that it was known to be physically easier to do. He obtained good results using the Vredenburg girdler. One researcher (A. Banner, pers. comm., 1990) girdled in January and still had bridging problems, although the treatment appeared to be effective.

Extensive breakage may occur at the point where the stem is girdled (Williams 1987; Pollack and LePage 1990). This can result in slash accumulations that restrict travel by both wildlife and humans. Seedlings may be damaged and alder may sprout if breakage occurs during the 1st year.

Two studies are monitoring succession under the girdled stands,[26, 27] but results are available for only the Salvus study.[28] In that study, girdling the overstorey has resulted in a large increase in the cover of the understorey vegetation.

Salmonberry

Introduction

The salmonberry complex is found on fresh to wet sites in the CDF and CWH in coastal British Columbia. Major species found in this complex include salmonberry, thimbleberry, vine maple and currant. In contrast to that in the red alder — shrub complex, the salmonberry in this complex tends to occur in dense thickets. Red alder is notably absent.

Literature Review

Recent studies on the population dynamics and growth of salmonberry (Maxwell 1990), and related research investigating its persistence (Tappeiner *et al.* 1990) are under way in Oregon. In addition, preliminary results show that salmonberry may be controlled by 2 years of pre-harvest cutting (J. Zasada, pers. comm., 1990).

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[23] Hedin, I. 1983. A comparison of productivity of girdling and hack and squirt techniques in conifer release. FERIC, Vancouver, B.C. Interim Report IR-383-2. Unpubl. report.

[24] Beese, W.J. 1985. Manual alder control: a review with recommendations. Presentation to the MacMillan Bloedel Annual Foresters Meet., Jan. 17–18, Qualicum, B.C. Unpubl. report.

[25] Eastwood, J. 1985. Assessment of alder girdling operations final report. B.C. Min. For., Silv. Br., Victoria, B.C. Unpubl. report. SX84708.

[26] Banner, A. 1988. Selective versus complete girdling of red alder stands on a coastal slope near Prince Rupert, B.C.: response of understorey vegetation and conifer regeneration. Working plan. B.C. Min. For., Prince Rupert For. Reg., Smithers, B.C. Unpubl. report.

[27] Inselberg, A.E., A. Banner, S. Thomson, and J. Pojar. 1990. Conversion of multi-storied brushfields to coniferous plantations: secondary plant succession: third year progress report. B.C. Min. For., Prince Rupert Region, Smithers, B.C. Unpubl. report.

[28] Banner, A. 1988. Selective versus complete girdling of red alder stands on a coastal slope near Prince Rupert, B.C.: response of understorey vegetation and conifer regeneration. Working plan. B.C. Min. For., Prince Rupert For. Reg., Smithers, B.C. Unpubl. report.

Roberts (1980) cut salmonberry at three time periods, and noted only a slight difference in height growth between the three treatment times. After two growing seasons, salmonberry cut in the late foliar period (August/September) was 0.9 m tall, while salmonberry cut in the early foliar (June) and dormant (March) periods was 1.1 m and 1.3 m, respectively.

Wagner (1984), noted that manual brushing slightly reduced salmonberry crown volume in the first growing season after treatment on a range of sites in Washington and Oregon. By the second growing season, however, rapid sprouting had increased crown volume to 29% higher than in the pre-treatment level.

Research in British Columbia

D'Anjou (1990b) reports that salmonberry recovered to 90% of its pre-treatment height and 60–90% of its pre-treatment cover during the first growing season following cutting. The number of stems did not increase significantly in this time period. D'Anjou also reports that manual cutting during five different phenological stages did not have any notable effect on salmonberry growth.

Operational Experience

In the Mid-Coast District near Bella Coola, it is necessary to manually brush salmonberry twice in one growing season for effective control (J. McClarnon, pers. comm., 1990). MacMillan Bloedel foresters gave an efficacy rating of 6 out of 10 to cutting for controlling salmonberry (W. Beese, pers. comm., 1990). Cutting salmonberry during June, July or August may result in less sprouting than cutting at other times (T. Turpin, pers. comm., 1990). Ungulates are very fond of young salmonberry shoots, and may help control salmonberry following cutting (T. Turpin, pers. comm., 1990; J. Zasada, pers. comm. 1990).

Discussion

Research and anecdotal information indicate that salmonberry is a rapid sprouter (Roberts 1980; D'Anjou 1990b; Wagner 1984; J. McClarnon, pers. comm., 1990). Although cutting of salmonberry in June, July or August may reduce both numbers of sprouts and height of salmonberry, these differences appear to be small and short-lived.

No studies have tested multiple cuttings of salmonberry, although one operational report suggested that they may be necessary (J. McClarnon, pers. comm., 1990). Preliminary results suggest that cutting for 2 years before harvesting may help reduce salmonberry's competitive ability (J. Zasada, pers. comm., 1990).

Using ungulates to help control salmonberry requires knowledge of local ungulate populations, and may give highly variable results.

Salal

Introduction

The salal complex occurs across a range of moisture regimes, from very dry to wet, in the CDF and CWH zones. It is a common and often serious competitor with conifers in low-elevation areas in coastal British Columbia. Salal has an extensive root system and is thought to be a very efficient below-ground competitor, particularly for moisture on drier sites. Salal may also reduce the availability of nutrients to conifers and may be allelopathic.

Literature Review

Haeussler *et al.* (1990) suggest that sprouting should be expected following manual cutting of salal.

Research in British Columbia

The effects of chemical and manual treatments on salal and conifer development have been compared. Repeated manual pulling of salal was as effective or more effective than the herbicides tested. Manual pulling enhanced Douglas-fir stem diameter growth, but was not considered practical since salal roots are extensive and abundant. D'Anjou speculated that enhanced Douglas-fir stem diameter was due to greater moisture availability.

Discussion

The effects of manual cutting on salal are not well documented. Although research has been conducted using manual techniques to remove salal, no quantitative data are published on its sprouting ability.

Two studies (Dunsworth 1987b; D'Anjou 1989) report that improved Douglas-fir growth was correlated with reduced salal cover.

Mixed Shrub

Introduction

The mixed shrub complex is found on fresh to wet sites in the ICH, MS, ESSF and SBS zones. This complex contains a number of woody shrubs, herbaceous plants and ferns, including thimbleberry, raspberry, black twinberry, Douglas maple, Sitka alder, falsebox, elderberry, devil's club, false azalea, willow, red-osier dogwood, fireweed, lady fern and bracken.

Literature Review/Research in British Columbia

Several research trials have been initiated in this complex. A trial was set up near Blue River to investigate the efficacy of various rates and timing of glyphosate and manual cutting for controlling a variety of species (fireweed, raspberry, thimbleberry, oak fern, bracken, false azalea) (Whitehead *et al.* 1982). One year after treatment, manual cutting provided as good or slightly better control of the vegetation, but none of the treatments was effective for 2 years.

In the Horsefly District, another brushing trial was established that also included a manual treatment. One growing season after cutting, black twinberry, elderberry, Sitka alder and fireweed had regrown to pre-treatment heights. Damage to crop seedlings from manual brushing was 20% (Newsome 1988).

Four treatment options (control, 2,4-D amine, manual brushing and glyphosate) were studied at a site dominated by thimbleberry, raspberry and fireweed near Golden.[29] The effectiveness of the manual brushing and 2,4-D amine was found to be short-lived and "of little consequence." Glyphosate controlled all species well for 3 years.

Whitehead and King (1990) are working on a site near Nelson where plots have been manually brushed three times. Six plots were brushed in early July 1987, three of which were rebrushed in July 1989 and 1990. An additional three plots were left as controls. Weed control efficacy has not yet been reported.

A rate and timing trial comparing chemical and manual control of thimbleberry has been completed in the Kispiox District. Associated species were wild rose, red-osier dogwood and aspen. By the end of the first growing season, manual cutting was considered ineffective at all four treatment dates (late June, mid-July, early August and late August). By the end of the third growing season, vegetation cover had increased over the control for three of the four manual treatment dates. In contrast, application of glyphosate during the summer provided good to excellent vegetation control.[30]

The performance of conifers planted on sites prepared by four different treatments (burning, herbicides, mechanical scarification and manual brushing) are being assessed in the Arrow and Revelstoke Districts. Bracken, falsebox and fireweed are the main target species. With the manual treatment, annual fall weedings are conducted using hockey sticks and sandviks. The objective of the weeding in the fall is to reduce the impact of vegetation press, not to control competition. Results are inconclusive to date (C. Thompson, pers. comm., 1990).

Operational Experience

Many silviculturists noted the problem of vegetation press, as a result of herbaceous vegetation falling over and crushing crop trees, usually in conjunction with winter snow. Some silviculturists are using two manual cutting treatments in one growing season. A spring treatment is used to improve the light availability

[29] Whitehead, R.J. 1989. Comparison of four treatment options for weeding shrub dominated spruce plantations. Expert Committee on Weeds (ECW). West. Canada Section Meet., Nov. 28–30, Banff, Alta. Res. Report, p. 222. Unpubl. report.

[30] LePage, P. 1989. Site preparation rate x timing trial for thimbleberry control. Expert Committee on Weeds (ECW). West. Canada Section Meet., Nov. 28–30, Banff, Alta. Res. Report, p. 213. Unpubl. report.

during the growing season; a summer or fall treatment is used to reduce the vegetation press problem (D. Greenley, pers. comm., 1990; P. Love, pers. comm., 1990). Significant resprouting is expected, making annual retreatment necessary. Fireweed generally recovers to pre-treatment heights (up to 2 m) during the first growing season after treatment (J. Annunziello, pers. comm., 1990; P. Comeau, pers. comm., 1991).

Crop trees are often difficult to find in this complex, and a variety of techniques are being tried to reduce damage. Hockey sticks have been used as an alternative to severing fireweed stems. They are used to "whack" or bend the brush from around the crop tree. However, because hockey sticks do not have a cutting surface, damage may be reduced (J. Annunziello, pers. comm., 1990; T. Johnston, pers. comm., 1990). Hand pulling and scythes are also being tried.

Discussion

Studies to date indicate that one manual treatment is not sufficient to control vegetation in this complex. Since most of the species in this complex sprout vigorously and increase in cover after treatment, annual retreatment is usually necessary. Glyphosate has been shown to be more effective than manual brushing on a number of species in this complex (e.g., thimbleberry and fireweed). Sheep grazing is also being tried in various regions of the province.

Damage to the crop trees from manual treatments is a concern because of the poor visibility of crop seedlings. A variety of tools and techniques are being examined to reduce crop seedling damage. Hockey sticks and similar implements are being tried to whack or bend the vegetation away from crop seedlings.

Ericaceous Shrub

Introduction

Rhododendron, false azalea and *Vaccinium* spp. are the main species in this complex, which is found on dry to moist sites in the ICH and ESSF zones.

Literature Review/Research in British Columbia

Research completed in this complex is summarized by Haeussler *et al.* (1990). Coates (1987) found that white-flowered rhododendron, false azalea and *Vaccinium* regrow less than 17% of their pre-treatment height at the end of the second growing season following cutting. After one growing season, 97% of all cut rhododendron stems sprouted with an average of 6.3 new sprouts per stem.[31] However, the average length of each of these stems was only 3.1 cm.

Operational Experience

Brush problems can be avoided in this complex if sites are prepared and planted promptly (J. Annunziello, pers. comm., 1990; J. Przcezek, pers. comm., 1990). Silviculturists noted that there was often a shift to a vigorous herbaceous community following prescribed burning on these sites. Because of this they felt prescribed burning might result in increased brush problems on these sites. This species shift may also occur following mechanical site preparation and brushing treatments.

Discussion

If sites in this complex are promptly prepared and planted after logging, future brush control may not be needed. Prescribed burning and mechanical disturbance may cause a species shift to a vigorous herbaceous community, particularly on wetter sites. If brush control is required, manual brushing may be effective for controlling white-flowered rhododendron, false azalea and *Vaccinium*.

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[31] Skakun, A.M. 1990. Regeneration of white-flowered rhododendron (*Rhododendron albiflorum*) after manual cutting on a clearcut site within the ESSFc subzone: first year growth response. Prepared for Assoc. B.C. Prof. Foresters. Unpubl. report.

Dry Alder

Introduction

This complex is found on dry to fresh sites in the IDF, ICH, MS, and SBS zones. The major species are Sitka alder, fireweed and pinegrass.

Literature Review/Research in British Columbia

Cutting Sitka alder was tested at different times of the year, from mid-winter to after leaf-fall (D. Lloyd, pers. comm., 1991). Treatment timing did not significantly affect the number of sprouts or height of Sitka alder in the 2nd year after treatment. The cut alder was 80 cm tall at the end of the 2nd year following treatment. After cutting, alder are expected to take 4 or 5 years to recover to pre-treatment height. Two growing seasons after manual cutting, Simard (1989) found that Sitka alder clumps sprouted to a mean height of 70 cm and a mean diameter of 7.3 cm. The tallest stems (125 cm) reached 42% of the pre-treatment height (3 m).

On drier grassy sites, alder was found to sprout less than alder on medium sites (0–25 cm in one year on drier sites compared to an average of 80 cm on medium sites).[32]

Operational Experience

In the Penticton District, one researcher did some informal trials to test the effects of timing, height of cut, and site factors. He found that cutting during a 4-week window in the hottest part of July and August reduced the number and height of Sitka alder sprouts (L. Gilloch, pers. comm., 1990). The height of the cut did not make any difference, and alder sprouted less on drier sites. During the hot summer, cutting was also effective in reducing sprouting in the Kelowna area (S. Clayton-Brown, pers. comm., 1990).

Discussion

Summer drought appears to influence the ability of Sitka alder to resprout on these sites. Research and operational experience suggest that manual cutting can be effective for controlling Sitka alder on drier sites. Research suggests that while time of cutting may have an effect on alder growth during the first growing season after treatment, these effects may not be evident in subsequent years.

Wet Alder

Introduction

The wet alder complex occurs on moist to wet sites in the ICH, MS, SBS, BWBS and ESSF zones. In addition to Sitka alder, other species present may include mountain alder, thimbleberry, black twinberry, reedgrass, lady fern, spiny wood fern and cow parsnip.

Literature Review/Research in British Columbia

Sitka alder sprouts more vigorously on richer, wetter sites than on poorer, drier sites (Haeussler *et al.* 1990). Following cutting, alder sprouts in one trial grew more vigorously on medium sites than on drier grassy sites (80 cm on medium sites compared to 0–25 cm on drier sites in the 1st year).[33]

Another study investigated the effects of four manual treatment timings (late May, late June, early August, early September) on the sprouting ability of Sitka alder in the Kootenay Lake District.[34] After one growing season, August and September cutting gave the largest reductions in per cent cover, but these reductions were small.

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[32] Noble-Hearle, G. 1988. Treatment effectiveness checks: brushing and weeding program. B.C. Min. For., Penticton For. Dist., Penticton, B.C. Unpubl. report.

[33] Noble-Hearle, G. 1988. Treatment effectiveness checks: brushing and weeding program. B.C. Min. For., Penticton For. Dist., Penticton, B.C. Unpubl. report.

[34] Hanlon, L. 1987b. Efficacy of manual treatment timing on Sitka alder in immature Englemann spruce: interim report. B.C. Min. For., Nelson Region, Nelson, B.C. Unpubl. report. SX86705N.

Operational Experience

An informal trial on the effect of time of cutting on Sitka alder response was conducted in the Cranbrook District. No effect of cutting time was found, and it was learned that Sitka alder flushes all growing season (J. Przcezek, pers. comm., 1990). In the Arrow District, Sitka alder sprouted 1 m or more in this first growing season after manual cutting (A. Skakun, pers. comm., 1991).

Discussion

Due to vigorous sprouting, single manual cutting treatments are unlikely to give effective control of Sitka alder or other species found in this complex. At present, no information exists on the effects of repeated cutting treatments.

Dry Shrub

Introduction

The dry shrub complex is found in the Interior, on dry to fresh sites in the IDF, ICH, MS and SBS zones. Major species include Saskatoon, *Ceanothus*, falsebox, soopolallie, common snowberry, oceanspray and Pacific ninebark.

Literature Review/Research in British Columbia

Only one study on manual brushing is in progress in this complex (C. Thompson, pers. comm., 1990). Near Golden, on a site dominated by falsebox, soopolallie, aspen and thimbleberry, vegetation was cut using brushsaws in late July. Vigorous sprouting has been noted, but more detailed results are not yet available.

Discussion

Very little has been done on manual brushing in this complex. Some information on Ceanothus spp. is available from the U.S. (e.g., Petersen and Newton 1985) where it is known to be a vigorous sprouter. However, it has not been studied in British Columbia. In fact, autecological information is available on only one other major species in this complex, common snowberry. It will sprout after cutting and is known to be tolerant to heavy grazing (Haeussler *et al.* 1990).

Willow

Introduction

Willow forms pure stands on moist to wet sites in many zones, including the IDF, ICH, MS, ESSF, SBS and BWBS. These stands usually occur after an intense disturbance (such as wildfire) exposes mineral soil to abundant, wind-borne seed.

Literature Review/Research in British Columbia

A recent paper by Pollack *et al.* (1990) summarizes the results of a variety of treatments tested to control willow in the SBS zone in the Prince Rupert Region. Manual cutting, 2,4-D ester and liquid hexazinone did not control willow. Hexazinone (10% granular formulation or undiluted with a spot gun application) and foliar applications of glyphosate were effective. Following manual cutting, sprouts were numerous and averaged 2.7–4.2 per cut stem. Regrowth can be rapid, with willow reaching heights of 74 cm within two growing seasons of cutting. Survival of cut willow was also high (96% after 2 years). Results indicate that manual cutting may be useful to improve availability of moose browse.

Bancroft (1990) reported that cutting willow produced a significantly greater number of sprouts than did herbicide treatments.

As discussed under "Mixed Hardwoods," cutting in late summer may slightly reduce willow cover.

Discussion

Willow is a very vigorous sprouter and one manual cut does not effectively control it. Preliminary results suggest that cutting in late summer may slightly reduce willow's sprouting ability.

Pinegrass

Introduction

Pinegrass is the most abundant grass in forested areas of the southern Interior. It is found on dry to fresh sites in the PP, IDF, ICH, MS, ESSF, SBS and BWBS zones, and is widespread in the IDF and MS zones where it dominates the understorey on a range of sites.

Discussion

The effects of manual cutting on pinegrass are summarized in Haeussler *et al.* (1990). Stout *et al.* (1981) report that environmental conditions, particularly summer rainfall, affect pinegrass's response to manual cutting. They also reported that an intensive clipping program (clipped to 10 cm in height over four consecutive summers) was required to produce a decline in pinegrass growth. Clipping is very labour-intensive and the results are short-lived.

Reedgrass

Introduction

Bluejoint reedgrass forms pure stands primarily on moist to wet sites in the SBS and BWBS zones, but it is also found in the ICH and ESSF.

Discussion

Heavy or repeated cutting will reduce bluejoint vigour (Haeussler *et al.* 1990).

Fern

Introduction

The major species in this complex are lady fern and spiny wood fern, although bracken is also often present. This complex grows on fresh to wet sites in the ICH, ESSF, SBS and BWBS zones.

Discussion

Cutting lady fern or bracken in mid-summer provides control only until the following spring. Repeated cutting over 3 successive years does reduce the size of lady fern, but appears to have little effect on bracken. Following cutting in June in the ICH, ferns (lady fern and bracken) regrow vigorously, reaching heights similar to untreated plants by the end of July (P. Comeau, pers. comm., 1990).

Bracken

Introduction/Discussion

Bracken occurs in pure stands in the ICH, ESSF and SBS zones on dry to wet sites.

Haeussler *et al.* (1990) report that repeated cutting at relatively frequent intervals (3 or more times per year) over a period of years is necessary for successful control. Timing is important. The first cut should be made before the frond is fully expanded and the second should follow about 6 weeks later.

Cutting bracken in mid-summer provides control only until the following spring. Cutting once annually for 3 successive years does not appear to reduce the vigour of bracken (P. Comeau, pers. comm., 1990). No operational experience with manual cutting of pure stands of bracken was reported by silviculturists.

Fireweed

Introduction

Fireweed is common on a range of sites throughout much of British Columbia, in the CDF, CWH, IDF, ICH MS, ESSF, SBS, SBPS and BWBS zones. It is more of a concern in the Interior, where it may dominate a site for a decade or longer.

Research in British Columbia

Cutting fireweed in late July or August effectively controls fireweed for the balance of the growing season. Cutting earlier in the growing season (mid- to late June) can result in significant sprouting of fireweed, with fireweed heights reaching 60 cm or more by late July. Cutting repeated annually during mid- to late July over a 3-year period reduced fireweed height and cover to about 60% of untreated control areas (P. Comeau, pers. comm., 1991).

Operational Experience

Instead of severing fireweed stems, hockey sticks can be used to bend fireweed away from crop seedlings. This appears to be effective from June to September. However, the effects are short-lived and last for only 1 year. Without repeat treatments, fireweed will return to untreated cover and height during the subsequent growing season (T. Johnston, pers. comm., 1990).

Discussion

In fireweed communities, manual cutting treatments are most successful if conducted during full leaf-out, from late July through August in the southern Interior. Treatments may have to be repeated annually to achieve improvements in conifer growth and survival.

Hockey sticks have also been used to control fireweed. To reduce the need for retreatment in the same growing season, the best time to use hockey sticks is from June to September. Repeat treatments in the following growing season are also required with this treatment.

When used near the end of the growing season, cutting or bending fireweed will reduce the problem of vegetation press.

Subalpine Herb

Introduction/Discussion

This complex is restricted to fresh to wet sites in the ESSF zone.

Major species include Sitka valerian, arrow-leaved groundsel, Indian hellebore, woodrush and fireweed. The complex dominates highly disturbed sites, such as skid trails and blocks logged in the summer (Caza 1988).

Haeussler *et al.* (1990) report that open-grown Sitka valerian is able to regain 1.5 times its original height within 6 weeks of cutting. On the other hand, shade-grown plants recover slowly. Multiple cuts may reduce the vigour of this species.

Coates (1988) reports that two growing seasons after cutting, both Sitka valerian and Indian hellebore recovered to pre-treatment levels. One operational manual brushing trial has been set up in the Vernon District, but results are not yet reported (D. Purdy, pers. comm., 1990).

Introduced Grasses

Introduction/Discussion

This complex is found on various sites in the Interior of the province, in the PP, IDF, ICH, MS, ESSF, SBS, BWBS zones. The main species are domestic grasses that have been sown for range land. No research has been done on the effectiveness of manual cutting for controlling these grasses.

APPENDIX 2. Biogeoclimatic zones of British Columbia (locations and symbols)

APPENDIX 3. List of Contacts

J. Annunziello, Kootenay Lake Forest District
B. Bancroft, Madrone Consultants
A. Banner, Prince Rupert Region
A. Barclay, Boundary Forest District
B. Beard, Revelstoke Forest District
W. Beese, MacMillan Bloedel
C. Beliveau, Invermere Forest District
R. Bigley, Washington State Department of Natural Resources
J. Blake, Revelstoke Forest District
J. Boateng, Silviculture Branch
R. Bowden, Prince George Region
S. Clayton-Brown, Fletcher Challenge
G. Burton, Fletcher Challenge
J. Casteel, Lakeland Mills
P. Chalifour, Kispiox Forest District
G. Chapman, Williams Lake Forest District
D. Coates, Prince Rupert Region
P. Comeau, Forest Science Research Branch
B. D'Anjou, Vancouver Region
H. Dawson, Prince George Region
B. Dobbs, Boundary Forest District
S. Dunn, Campbell River Forest District
G. Dunsworth, MacMillan Bloedel
R. Enfield, Clearwater Forest District
P. Eng, Squamish Forest District
S. Gillette, Zeidler Brothers
L. Gilloch, Penticton Forest District
M. Grainger, North Coast Forest District
B. Granger, Brinkman and Associates
R. Gray, Kamloops Region
D. Greenley, Horsefly Forest District
R. Greschner, Sunshine Coast Forest District
L. Hanlon, Kootenay Lakes Forest District
T. Harrington, Oregon State University, CRAFTS
I. Hedin, FERIC
O. Helgerson, Oregon State University, FIR
L. Herring, Prince George Region
D. Horn, Lillooet Forest District
J. Jang, Pentiction Forest District
T. Johnston, Arrow Forest District
D. Keating, Skeena Sawmills
E. Korpela, Oregon State University, FIR
B. Lasuto, Interfor
V. Lieffers, University of Alberta
P. Lishman, Kamloops Forest District
D. Lloyd, Kamloops Region
P. Love, Rustad Brothers
A. MacDonald, Skeena Cellulose
J. McClarnon, Mid-Coast Forest District
N. McIlveen, B.C. Hydro
G. McKee, Quesnel Forest District
A. McLeod, Canfor
S. McRuer, Port Alberni Forest District
E. Nedokus, Merritt Forest District
F. Newhouse, Consultant
G. Newsome, Williams Lake Forest District
J. Perry, Cariboo Region
F. Philpot, Consultant
J. Pollack, Nelson Region
A. Pollard, Golden Forest District
J. Przcezek, Cranbrook Forest District
D. Purdy, Vernon Forest District
G. Reichenbach, Nelson Region
S. Reygher, Weldwood
D. Routledge, West Fraser Mills
D. Roy, Canfor
S. Simard, Kamloops Region
M. Scott, Vancouver Region
D. Salayka, Robson Valley Forest District
A. Skakun, Arrow Forest District
C. Thompson, Nelson Region
L. Tromp, Prince Rupert Region
T. Turpin, Siuslaw National Forest
C. van Hemmen, Port McNeill Forest District
P. Veltmeyer, Westar
R. Whitehead, Forestry Canada
D. Williams, Queen Charlotte Forest District
B. Wilson, Kalum Forest District
J. Wright, Salmon Arm Forest District
J. Zasada, Oregon State University, Forest Sciences Lab

APPENDIX 4. Latin and common names of species mentioned in text

Abies balsamea	balsam fir
Acer circinatum	vine maple
Acer glabrum	Douglas maple
Acer macrophyllum	bigleaf maple
Acer spicatum	mountain maple
Alnus incana spp. *tenuifolia*	mountain alder
Alnus rubra	red alder
Alnus viridis spp. *sinuata*	Sitka alder
Amelanchier alnifolia	Saskatoon
Arctostaphylos patula	greenleaf manzanita
Athyrium filix-femina	lady fern
Betula papyrifera	paper birch
Calamagrostis canadensis	bluejoint
Calamagrostis rubescens	pinegrass
Ceanothus velutinus	snowbrush
Ceanothus sangineus	redstem Ceanothus
Cinna latifolia	nodding wood-reed
Cornus sericea	red-osier dogwood
Dryopteris assimilis	spiny wood fern
Epilobium angustifolium	fireweed
Gaultheria shallon	salal
Heracleum lanatum	cow-parsnip
Holodiscus discolor	oceanspray
Lonicera involucrata	black twinberry
Luzula spp.	woodrush
Menziesia ferruginea	false azalea
Oplopanax horridus	devil's club
Paxistima myrsinites	falsebox
Picea englemannii	Englemann spruce
Picea sitchensis	Sitka spruce
Pinus contorta	lodgepole pine
Polystichum munitum	swordfern
Populus balsamifera	balsam poplar
Populus tremuloides	trembling aspen
Physocarpus malveceus	Pacific ninebark
Psuedotsuga menziesii	Douglas-fir
Pteridium aquilinum	bracken
Quercus chrysolepis	canyon live oak
Rhododendron albiflorum	white-flowered rhododendron
Ribes spp.	gooseberry
Rubus parviflorus	thimbleberry
Rubus spectabilis	salmonberry
Salix spp.	willow
Sambucus racemosa	elderberry
Senecio triangularis	arrow-leaved groundsel
Shepherdia canadensis	soopolallie
Symphoricarpos albus	snowberry
Thuja plicata	western redcedar
Vaccinium spp.	blueberry
Valeriana sitchensis	Sitka valeriana
Veratrum viride	Indian hellebore

REFERENCES

Bancroft, B. 1978. Brush control: a cost effectiveness analysis for conifer release from red alder. M.R.M. thesis. Simon Fraser Univ., Burnaby, B.C.

_____. 1989. Response of aspen suckering to pre-harvest stem treatments: a literature review. B.C. Min. For., Res. Br., Victoria, B.C. FRDA Report 087.

_____. 1990. Effect of glyphosate on vegetation and forage resources in moose winter range in the SBS zone. B.C. Min. For., Res. Br., Victoria, B.C. FRDA Memo 161.

Bernstein, A. 1977. Seven immediate consequences of use of a chainsaw to control brush. *In* Proc. 1977 Western For. Conf., Nov. 30–Dec. 1, Seattle, Wash., p. 100.

_____. 1978. Using a chainsaw to control brush. J. For. 76 (7):474–475.

Bigley, R. 1988. Ecological physiology of conifer seedling and sapling suppression by, and release from, competing vegetation. Ph.D. thesis. Univ. B.C., Vancouver, B.C.

Boateng, J. and G. Ackerman. 1990. A guide to vegetation control equipment. B.C. Min. For., Silv. Br., Victoria, B.C. FRDA Handb. 005.

B.C. Ministry of Forests. 1981. Annual report, 1980/81. Victoria, B.C.

_____. 1982. Annual report, 1981/82. Victoria, B.C.

_____. 1983. Annual report, 1982/83. Victoria, B.C.

_____. 1984. Annual report, 1983/84. Victoria, B.C.

_____. 1985. Annual report, 1984/85. Victoria, B.C.

_____. 1986. Annual report, 1985/86. Victoria, B.C.

_____. 1987. Annual report, 1986/87. Victoria, B.C.

_____. 1988. Annual report, 1987/88. Victoria, B.C.

Caza, C. 1988. Vegetation and Engelmann spruce performance on NSR backlog in the ESSFm. B.C. Min. For., Res. Br., Victoria, B.C. FRDA Memo. No. 010.

Coates, D. 1987. Effects of shrubs and herbs on conifer regeneration and microclimate in the *Rhododendron-Vaccinium-Menziesia* community in south-central British Columbia. M.Sc. thesis. Oreg. State Univ., Corvallis, Oreg.

_____. 1988. Rehabilitation of the *Rhododendron-Vaccinium-Menziesia* brush community. B.C. Min. For., Res. Br., Victoria, B.C. FRDA Memo No. 011.

D'Anjou, B. 1989. Impact of chemical and manual treatments on salal and conifer development — phase 1. Expert Committee on Weeds (ECW). West. Canada Section Meet., Nov. 28–30, Banff, Alta. Res. Report, p. 209.

D'Anjou, B. 1990a. Effect of manual treatment timing and glyphosate on non-crop vegetation development. B.C. Min. For., Res. Br., Victoria, B.C. FRDA Memo No. 141.

_____. 1990b. Growth response of several vegetation species to herbicides and manual cutting treatments in the Vancouver Forest Region. B.C. Min. For., Res. Br., Victoria, B.C. FRDA Report 135.

DeBell, D.S. and T.C. Turpin. 1989. Control of red alder by cutting. Res. Paper PNW-RP-414, Pac. NW Res. Sta., U.S. Dep. Agric. For. Ser., Olympia, Wash.

Dunsworth, G. 1987a. Northwest Bay brush control. Expert Committee on Weeds (ECW). West. Canada Section Meet, Dec. 1–3, Victoria, B.C. Res. Report, p. 196.

_____. 1987b. Salal removal and its impact on crop tree performance. Expert Committee on Weeds (ECW). West. Canada Section Meet., Dec. 1–3, Victoria, B.C. *In* Res. Report, p. 197.

Ehrentraut, G. and K. Branter. 1990. Vegetation management by manual and mechanical means in Alberta boreal forests. For. Chron. Aug. 1990, pp. 366–368.

Haeussler, S., D. Coates, and J. Mather. 1990. Autecology of common plants in British Columbia: a review. B.C. Min. For., Res. Br., Victoria, B.C. FRDA Report 158.

Harrington, C. 1984. Factors influencing initial sprouting of red alder. Can. J. For. Res. 14:357–361.

Harrington, T. and R.G. Wagner. 1986. Three years of Douglas-fir growth and survival following six competition release treatments in the Oregon and Washington coast. Oreg. State Univ., CRAFTS, Corvallis, Oreg.

Hobbs, S.D. and K.A. Wearstler, Jr. 1985. The effects of cutting sclerophyll brush on sprout development and Douglas-fir growth. For. Ecol. Manage. 13:69–81.

Hogg, E.H. and V.J. Lieffers. 1991. Seasonal changes in shoot regrowth potential in *Calamagrostis canadensis*. Oecologia 85(4):596–602.

Holmsen, S.D. 1990. Comparison of four single stem methods for controlling trembling aspen. FERIC, Vancouver, B.C. Special Report No. SR-70.

Holmsen, S.D. and R.J. Whitehead. 1988. Comparison of clearing — saw attachments for weeding young plantations. B.C. Min. For., Res. Br., Victoria, B.C. FRDA Report 028.

Hoyer, G.E. and D. Belz. 1984. Stump sprouting related to time of cutting red alder. Wash. State Dep. Nat. Res. Report 45.

Kimmins, J.P. and P.G. Comeau. 1990. Forest vegetation management research strategy for the southern interior, British Columbia. B.C. Min. For., Res. Br., Victoria, B.C. FRDA Report 132.

MacLean, D.A. and M.G. Morgan. 1983. Long-term growth and yield response of young fir to manual and chemical release from shrub competition. For. Chron., Aug. 83, pp. 177–183.

McLennan, D. 1990. Management of black cottonwood, red alder, bigleaf maple, and paper birch in coastal British Columbia. B.C. Min. For., Res. Br., Victoria, B.C. FRDA Memo No. 133.

Maxwell, B.D. 1990. The population dynamics and growth of salmonberry and thimbleberry. Ph.D. thesis. Oreg. State Univ., Corvallis, Oreg.

Messier, C. and J.P. Kimmins. 1988. Below-ground interactions between salal and coniferous crop seedlings in the CWHb on northern Vancouver Island: 2.31 File Report. B.C. Min. For., Res. Br., Victoria, B.C. FRDA Project.

Newsome, G. 1988. MacKay herbicide trial: first year assessment. B.C. Min. For., Silv. Br., Victoria, B.C. SX85702C.

Newton, M. and P. Comeau. 1990. Control of competing vegetation. *In* Regenerating British Columbia's forests. D.P. Lavender, R. Parish, C.M. Johnson, G. Montgomery, A. Vyse, R.A. Willis and D. Winston (editors). Univ. B.C. Press, Vancouver, B.C., pp. 256–265.

Pendl, F. and B. D'Anjou. 1990. Effect of manual treatment timing on red alder regrowth and conifer response. B.C. Min. For., Res. Br., Victoria, B.C. FRDA Report 112.

Petersen, T.D. and M. Newton. 1985. Growth of Douglas-fir following control of snowbrush and herbaceous vegetation in Oregon. Down to Earth 41 (1):21–25.

Pollack, J. and P. LePage. 1990. Relative costs of red alder-to-conifer site conversion, FRDA Project 2.06. B.C. Min. For., Res. Br., Victoria, B.C. FRDA Memo No. 145.

Pollack, J.C., P. LePage, and F. van Thienen. 1990. Some effects of different forest herbicides on upland *Salix* spp. Can. J. For. Res. 20:1271–1276.

Roberts, C. 1977. Vegetative response to manual brush control. *In* Proc. 1977 West. For. Conf., Nov. 30–Dec. 1, Seattle, Wash.

_____. 1980. Cooperative brush control study: 2nd year report. Project co-ordinated with Oreg. State Univ., For. Res. Lab., Corvallis, Oreg.

Schier, G.A. 1978. Root suckering in young aspen girdled, defoliated, and decapitated at various seasons. *In* Proc. 5th North Am. For. Biol. Workshop. A. Hollis and A.E. Squillace (editors). Univ. Fla., School For. Resources Conserv., Gainesville, Fla., pp. 259–267.

Simard, S.W. 1989. Competition among Lodgepole pine seedlings and plant species in a Sitka-alder dominated shrub community in the southern interior of British Columbia. M.Sc. thesis. Oreg. State Univ., Corvallis, Oreg.

Stout, D.G., J. Hall, B. Brooke, and A. McLean. 1981. Influence of successive years of simulated grazing (clipping) on pinegrass growth. Can. J. Plant Sci. 61: 939–943.

Tappeiner, J., J. Zasada, P. Ryan, and M. Newton. 1991. Salmonberry clonal and population structure in Oregon forests: the basis for persistent cover. Ecology 72(2):609–618.

Wagner, R.G. 1984. Two-year responses of eight coast range brush species to six release treatments. Oreg. State Univ., CRAFTS. Corvallis, Oreg.

_____ _____. 1987. First-year results from treatments to control bigleaf maple sprouts. Oreg. State Univ., CRAFTS. Corvallis, Oreg.

Waldron, R.M. 1961. Girdling, basal spraying and frilling of mature aspen. Timber of Canada 22 (12):34–35.

Weaver, D. 1983. Vredenburg girdling tool trial. For. Chron. 59 (5):260–261.

Whitehead, R.J., J.R. Gilmour, and G.C. Ackerman. 1982. Blue River herbicide trial: final report. B.C. Min. For., Silv. Br., Victoria, B.C. SX79601Q.

Whitehead, R.J. and R.K. King. 1990. Damage assessment after clearing saw treatments for release of a young mixed conifer plantation from heavy shrub cover. Expert Committee on Weeds (ECW). Res. Report.

Williams, D. 1987. Underplanting of Sitka spruce seedlings below mechanically girdled red alder trees: interim report. B.C. Min. For., Silv. Br., Victoria, B.C. SX86102R.

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